DUMONT OSCILLOSCOPES

TYPE 403 AND 403-R

INSTRUCTION MANUAL

DUMONT

CATHODE-RAY OSCILLOSCOPES

TYPES 403 and 403-R

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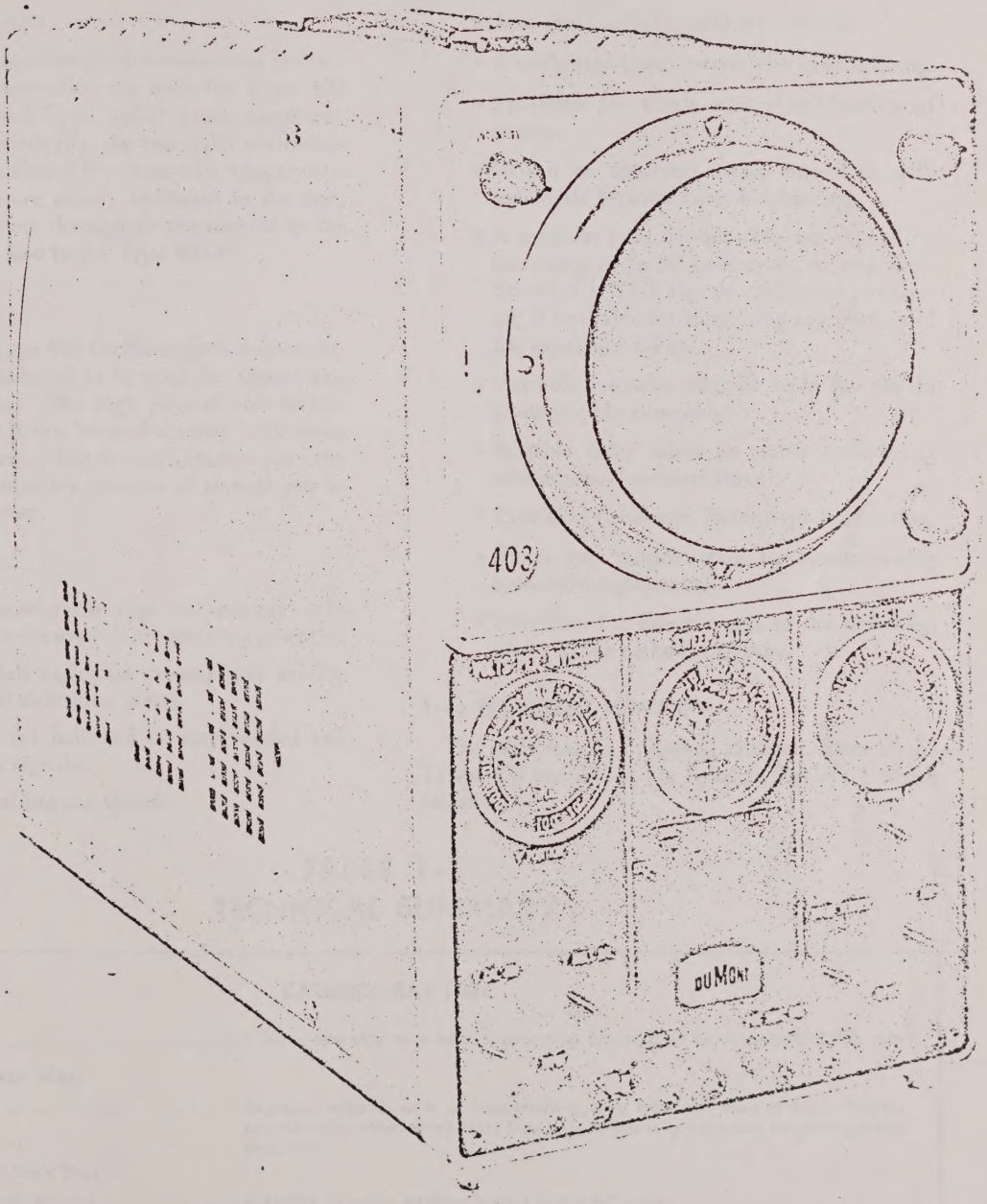


Figure 1-1. Type 403 Oscilloscope

SECTION 1
TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions contains information on both the Type 403 (bench model) and Type 403-R (rack mounted) Oscilloscopes. Electrically, the two types are identical; mechanically, they differ in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 403 pertain also to the Type 403-R.

1-2. PURPOSE

The Du Mont Type 403 Oscilloscope is a quantitative instrument designed to be used for almost any general application. The high gain of this instrument assures that it can be used directly with many types of transducers, while dc amplification provides that the lowest frequency portions of signals will be faithfully reproduced.

1-3. FEATURES

- A mono-accelerator type cathode-ray tube with 2500 volts over-all accelerating potential.
- A calibrated high-gain dc amplifier driving the vertical deflection plates.
- Provision for balanced or single-ended vertical input signals.
- Internal calibrating signal.
- Accurate vertical sensitivity controls.
- A calibrated linear sweep with sync limiting.
- Provision for single control calibration of sweep.
- Driven or recurrent sweep operation with automatic forward trace brightening.
- A medium gain dc amplifier for expanding the sweep up to 50 centimeters or amplification of X INPUT signals. Sufficient positioning is available for examining any portion of the expanded sweep.
- Variable intensity edge-lit scale for use in photographic recording.
- Suitable color filters to match cathode-ray tube screen characteristics.
- Provision for Z-axis (intensity) modulation.
- Sweep gate output signal for synchronizing associated equipment.
- Provision for direct access to the deflection plates of the cathode-ray tube.

1-4. TECHNICAL SUMMARY

The electrical and physical characteristics of the Types 403 and 403-R are listed in Table 1-1 which follows.

TABLE 1-1
TECHNICAL SUMMARY

CATHODE-RAY TUBE	
1-1. TYPE	5AQP—operated at a total accelerating potential of approximately 2500 volts
1-2. ILLUMINATED SCALE	
a. Scale	Engraved edge-lit scale and appropriate color filter over face of tube. Dimmer control varies illumination level from zero to intensity adequate for photographic recording
b. Vertical Scale Division	
1) Major division	0.3 inch; 10 major divisions total 3 inches full scale
2) Minor division	0.060 inch; located on vertical center line
c. Horizontal Scale Division	
1) Major division	1 centimeter; 10 major divisions total 10 centimeters full scale
2) Minor division	0.2 centimeter; located on horizontal center line

TABLE 1-1. TECHNICAL SUMMARY (Continued)

VERTICAL DEFLECTION AMPLIFIERS

2-1. INPUT COUPLING

a. Single-ended ..... Direct or through capacitor of 1000-volt rating to amplifier; all sensitivity settings
b. Balanced ..... Direct only; see 2-2b
c. Direct to Deflection Plates ..... Provision is made for direct connection to the deflection plates. For best focus, an average dc potential of 250 volts with respect to ground should be maintained

2-2. INPUT SENSITIVITY RANGE

a. Single-ended Signals

VOLTS PER DIVISION set to AC/DC	Sensitivity per division with MULTIPLIER set to:				
	X.1	X.5	X1	X2	X5
.001	100 μV	500 μV	1 mV	2 mV	5 mV
.01	*	5 mV	10 mV	20 mV	50 mV
.1	*	50 mV	100 mV	200 mV	500 mV
1	*	500 mV	1 volt	2 volts	5 volts
10	*	5 volts	10 volts	20 volts	50 volts

* For optimum bandwidth performance, it is recommended that these sensitivity settings be made in other combinations of input selector controls

1) Maximum grid signal ..... 0.5 volt unidirectional; 1 volt peak-to-peak

b. Balanced Signal

VOLTS PER DIVISION set to DC:	Sensitivity per division with MULTIPLIER set to:				
	X.1	X.5	X1	X2	X5
.001	100 μV	500 μV	1 mV	2 mV	5 mV
.01	1 mV	5 mV	10 mV	20 mV	50 mV

1) Maximum common mode signal .. 6 volts minus peak amplitude of observed signal
2) Maximum grid-to-grid signal ..... 1 volt peak-to-peak

c. Vertical Calibration Accuracy ..... Over-all accuracy of ±5% of full scale deflection

2-3. INPUT IMPEDANCE

a. Through Amplifier
1) Single-ended ..... 2 megohms, approximately 60 μμf
2) Balanced ..... 4 megohms, approximately 30 μμf

b. Direct to Deflection Plates
1) Single-ended ..... 2 megohms, 10 μμf
2) Balanced ..... 4 megohms, 10 μμf

2-4. DEFLECTION SENSITIVITY

a. Through Amplifier at Full Gain ..... 100 microvolts dc or peak-to-peak per division
b. At Deflection Plates ..... 10.5 volts dc or peak-to-peak ±10%, per division

TABLE 1-1. TECHNICAL SUMMARY (Continued)

2-5. ON-SCREEN DISPLAY

a. Expansion and Positioning ..... Any portion of four times full scale deflection can be positioned on screen

b. Linearity ..... Any 10% portion of the trace will be within 5% of any other 10% portion of the trace throughout the ten-division full scale limit

c. Undistorted Deflection (varies with sensitivity settings as tabulated below)

VOLTS PER DIVISION set to:	MULTIPLIER set to:	Maximum Undistorted Deflection
.001	[X.1, X.5, X1 or X2]	Unidirectional or symmetrical signal: 4 times full scale
[.01, .1 1 or 10]	X5	Unidirectional: full scale Symmetrical signal: twice full scale

2-6. SINUSOIDAL FREQUENCY RESPONSE
(Referred to sensitivity at 1 Kc)

a. High Frequency

1) 50 millivolts to 50 volts per division ..... Less than 30% down at 300 Kc

2) 500 microvolts to 50 millivolts per division ..... Improves from 30% down at 100 Kc to 30% down at 300 Kc as the range is increased

3) 100 microvolts per division ..... Less than 30% down at 60 Kc

b. Low Frequency

1) Direct coupled ..... Flat from dc to specified upper frequency limit

2) Capacitively coupled ..... Down not more than 30% at 1 cycle

2-7. PULSE RESPONSE (to a step function)

a. Rise Time ..... Less than 1.0 microsecond at all VOLTS PER DIVISION and MULTIPLIER settings at or over 50 millivolts; increases to 5 microseconds at maximum sensitivity

b. Overshoot ..... Less than 2%

c. Decay of top

1) Direct coupled ..... Less than 2% of deflection in 5 seconds

2) Capacitively coupled ..... Less than 10% in 45 milliseconds

2-8. AMPLITUDE CALIBRATION

a. Availability ..... To vertical amplifier by setting MULTIPLIER to the CAL position (input signal is thus automatically disconnected)

b. Waveshape and Frequency ..... Clipped sine wave at power-line frequency

c. Amplitude ..... 0.5 volt ±2%

HORIZONTAL DEFLECTION AMPLIFIER

3-1. SIGNAL SELECTION ..... X SELECTOR applies either ac or dc single-ended signals or sweep voltage to X amplifier, or the high-level sweep directly to the deflection plates

3-2. ATTENUATION ..... By ratio of 1 or 10 as determined by X SELECTOR (external signals only)

3-3. INPUT IMPEDANCE

a. Through Amplifier ..... 2 megohms, 50 μμf

b. Direct to Deflection Plates

1) Single-ended ..... 2 megohms, 10 μμf

2) Balanced ..... 4 megohms, 10 μμf

TABLE 1-1. TECHNICAL SUMMARY (Continued)

3-4. DEFLECTION SENSITIVITY	
a. Through Amplifier at Full Gain	3 volts dc or peak-to-peak for full scale deflection
b. At Deflection Plates	18 volts dc or peak-to-peak, per centimeter, ±10%
3-5. ON SCREEN DISPLAY	
a. Expansion and Positioning	Any portion of the X signal or the uncalibrated sweep, expanded to five times full scale deflection, can be positioned on the screen
b. Undistorted Deflection	No on-screen distortion will be noted over the visible portion of the expanded trace; reduced performance at sweep rates of 1 and 2 microseconds per centimeter
c. Linearity	Any 10% portion of the trace will be within 10% of any other 10% portion of the trace through the ten-centimeter full scale limit; reduced performance at sweep rates of 1 and 2 microseconds per centimeter
3-6. SINUSOIDAL FREQUENCY RESPONSE (Referred to sensitivity at 1 Kc)	
a. High Frequency	Down not more than 30% at 200 Kc
b. Low Frequency	
1) Direct coupled	Flat from dc to specified upper frequency limit
2) Capacitively coupled	Down not more than 30% at 1 cycle
3-7. BEAM GATE	Automatic beam brightening during forward sweep. Beam is not visible during sweep retrace or while sweep is at rest. INTENSITY control overrides blanking for X amplifier use The beam gate may be used to gate the beam on for a time interval determined by the SWEEP RATE and MULTIPLIER controls when the X amplifier is being used

SWEEP CIRCUIT

4-1. MODE	Vacuum tube sweep, driven or recurrent as desired
4-2. SWEEP WRITING RATE	
a. Internal	
1) Calibrated	From 1000 milliseconds to 1 microsecond per centimer in 19 steps
2) Uncalibrated	Continuously variable from 1000 milliseconds to 2 microseconds per centimeter
3) Accuracy	Within ±5% of product of SWEEP RATE and MULTIPLIER dial readings (calibrated sweep only)
b. External	External capacitors may be connected to extend the slow speed sweep range. See Section 2, Operation, for further details
4-3. SWEEP LENGTH	
a. Calibrated	10 Centimeters; +2 centimeters or −0 centimeter
b. Expanded	50 centimeters maximum (except at sweep rates of 1 and 2 microseconds/centimeter); 4 centimeters minimum
4-4. SWEEP LINEARITY	
a. Calibrated	Any 10% portion of the sweep will be within 3% of any other 10% portion of the sweep
b. Expanded	Any 10% portion of the expanded sweep will be within 15% of any other 10% portion, except for the first half microsecond which will be within 20% of any other portion (up to 2 μsec/cm)
4-5. SWEEP POSITIONING	
a. Calibrated	Up to ±3 centimeters
b. Exponded	50 centimeters total

TABLE 1-1. TECHNICAL SUMMARY (Continued)

4-6. BEAM GATE ..... See 3-7

SYNC CIRCUIT

5-1. SYNC SELECTION ..... Positive or Negative INTernal, power LINE, or EXTernal signal

5-2. SYNC SENSITIVITIES

a. Amplitude
1) INT ..... Sweep will synchronize on 1.25 divisions of vertical deflection (minimum)
2) EXT ..... Sweep will synchronize on 2 volts peak (minimum)

b. Signal Type ..... Sweep can be driven by sine waves from 2 cycles to 100 Kc, and pulses having rate of rise of 20 milliseconds to 23 milli-microseconds per volt; can be synchronized to 500 Kc in the recurrent mode

5-3. SWEEP STARTING TIME

a. INT ..... Less than 1.5 microseconds (time between 10% point on rise of sync pulse to 75% point on rise of sweep gate)

b. EXT ..... Less than 1 microsecond

INTENSITY MODULATION CIRCUIT

6-1. Z AXIS

a. Availability ..... Z INPUT terminal is provided on rear panel for signal input

b. Input Impedance ..... 39K ohms, 10 μμf

c. Frequency Response ..... 30% down at 250 cycles and 10 megacycles

d. Polarity and Sensitivity ..... Positive signals decrease beam intensity; 2 to 56 volts peak, depending on INTENSITY setting, will blank the beam

POWER SUPPLY

7-1. PRIMARY POWER REQUIREMENTS

*a. Line Voltage ..... 115 volts, ±10%, single phase

b. Line Frequency ..... 50 to 400 cycles

c. Power ..... Approximately 180 watts, 200 VA at nominal line

*A 230-volt transformer is available upon special order

7-2. HIGH-VOLTAGE SUPPLY

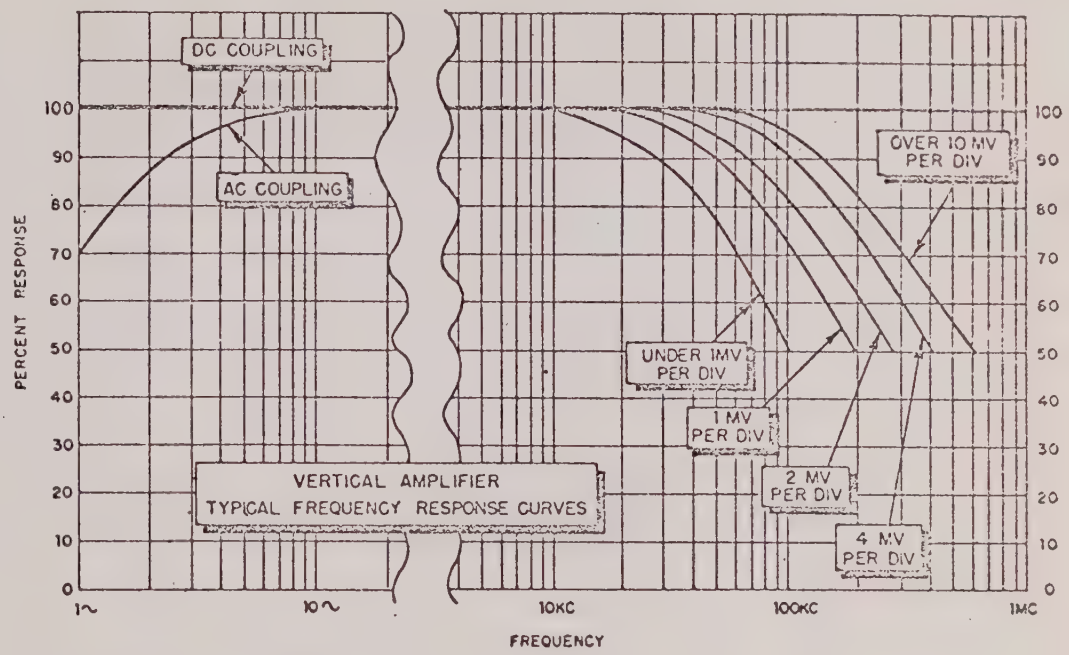
a. Type ..... An electronically regulated rf supply system for generating CRT accelerating potential is provided

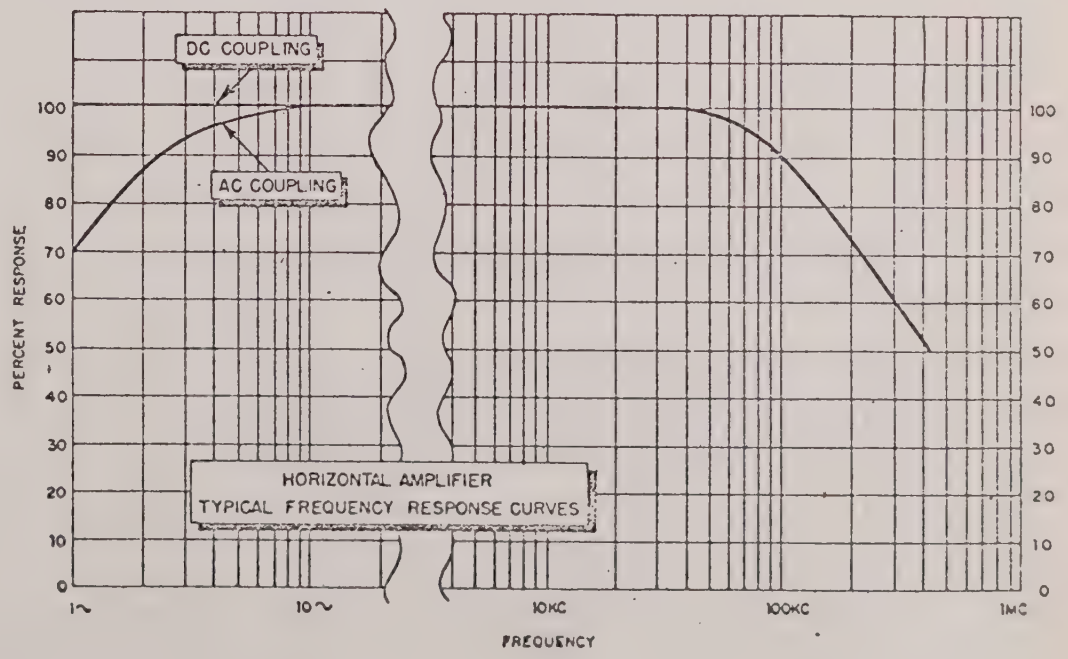
b. Regulation ..... ±2% over range of INTENSITY control

PHYSICAL CHARACTERISTICS

	TYPE 403	TYPE 403-R
Height	15 inches	8¾ inches
Width	8¾ inches	19 inches
Depth	20¾ inches	19 inches
Weight	Approximately 44 pounds	

TABLE 1-1. TECHNICAL SUMMARY (Continued)





SECTION 2
OPERATION

2-1. GENERAL

The Du Mont Types 403 and 403-R Oscilloscopes are shipped with all tubes in place and ready to operate. Since these instruments are portable, no special installation procedure is required. The —R model has a front panel 19 inches wide by 8¾ inches high for mounting the instrument in a standard relay rack or cabinet.

Normally the Type 403/403-R may be placed where most convenient for viewing while at the same time maintaining short signal leads. Although shielding has been provided, operation in very strong magnetic fields may cause spurious deflections and should be avoided. Reorientation or additional shielding of the instrument may be necessary to minimize the effects of such fields.

The instrument is intended for operation from a 50-400 cycle, single-phase, 115-volt power source and will operate satisfactorily with line-voltage variations of ±10%. Where line-voltage variations are excessive, and where extreme stability is required, it is suggested that a constant-voltage transformer of suitable power rating be employed in the power line to the instrument.

NOTE: Since the power supplies of this instrument are the capacitor-input type, relatively large peak currents are required from the primary mains. Hence, when using primary power from any other source, the generator employed must be capable of supplying these peak currents.

2-2. FRONT AND REAR-PANEL FACILITIES (TABLE 2-1)

The front and rear-panel markings are essentially self explanatory, and after carefully studying Table 2-1, the operator will find it possible to master the controls with a minimum of practice.

TABLE 2-1
FRONT AND REAR-PANEL FACILITIES

NAME	FUNCTION
FRONT-PANEL FACILITIES	
INTENSITY	Control: varies the trace brightness
FOCUS	Control: adjusts the trace sharpness
POWER/SCALE	Control with switch: dimmer control varies the illumination level of lamps to facilitate photographic retording of scale; switch attached provides means for turning primary power on or off
	Concentric controls:
VOLTS PER DIVISION	a. Outer knob provides for the direct reading of the input signal in volts per division for both capacitive or direct inputs when vertical amplifier is properly calibrated; it grounds the input stage of the vertical amplifier in the OFF position
MULTIPLIER	b. Inner knob multiplies VOLTS PER DIVISION settings by factors of 0.1, 0.5, 1, 2, or 5; connects calibrator signal to vertical amplifier in CAL position; facilitates Y MULT BAL adjustment in the BAL position
Y POSITION	Control: positions the trace vertically
Y CAL ADJ	Control: sets the gain of the vertical amplifier to provide the specified volt per division deflection with the CAL signal applied. See paragraph 2-7b
Y MULT BAL	Control: when properly adjusted, prevents vertical movement of the trace when switching through the VOLTS PER DIVISION and MULTIPLIER ranges. See paragraph 2-7a
Y INPUT	Binding posts: connections for external signals to the vertical amplifier, either balanced or single ended

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (Continued)

NAME	FUNCTION
FRONT-PANEL FACILITIES	
SWEEP RATE MULTIPLIER	Concentric controls: a. Outer knob provides adjustment of sweep writing rates from 100 milliseconds to 1 microsecond per centimeter in six steps. Provision for extending the low sweep rate is given in paragraph 2-5e b. Inner knob multiplies SWEEP RATE settings by factors 1, 2, 5, and 10; VERN position inserts SWEEP VERNIER control which enables continuous variation of sweep rate over a 10:1 range
SYNC SELECTOR	Control: selects source of sweep synchronizing signals (EXT, LINE, and INT)
SYNC AMPLITUDE	Control: selects polarity and adjusts the amplitude of sweep synchronizing signals
SYNC IN	Binding posts: provides for connection of external synchronizing signals to the EXT position of the SYNC SELECTOR
POS SYNC OUT	Binding posts: provides positive signals coincident with the start of the sweep to enable synchronization of auxiliary equipment
X SELECTOR SWEEP MODE	Concentric controls: a. Outer knob selects internal or external signal for the horizontal deflection. For internal signals, CALibrated or VARiable SWEEP is available. On external signals, either dc or ac coupling at attenuation ratios of 1 or 10 is provided. OFF position also provided b. Inner knob provides adjustment for either driven or recurrent sweep operation
X POSITION	Control: positions the trace horizontally
SWEEP VERNIER	Control: provides continuous variation of sweep writing rates within the limits established by the SWEEP RATE control when MULTIPLIER is set to VERN
X AMP	Control: provides continuous amplitude adjustment of horizontal deflection when X SELECTOR is set to AMPLIFIER or VARiable SWEEP
X INPUT	Binding posts: connections for external signals to the horizontal amplifier when X SELECTOR is set to AMPLIFIER
Y CAL ADJ DC BAL (left side of cabinet)	Screwdriver control: when properly adjusted, prevents vertical movement of the trace when the Y CAL ADJ control is varied. See paragraph 2-7a
SWEEP CALIBRATE (right side of cabinet)	Screwdriver control: an adjustment for overall sweep calibration. See paragraph 2-5b
REAR-PANEL FACILITIES (Accessible at Rear of Cabinet or Dust Cover)	
*D1 (left) and D2 (right)	Turret lugs: provide for direct connection of signals to the horizontal deflection plates
*D3 (up) and D4 (down)	Turret lugs: provide for direct connection of signals to the vertical deflection plates
Z INPUT	Turret lugs: provide for connection of external signals for intensity modulation of the trace

* Data in ( ) indicates the direction of deflection resulting from the application of a positive signal

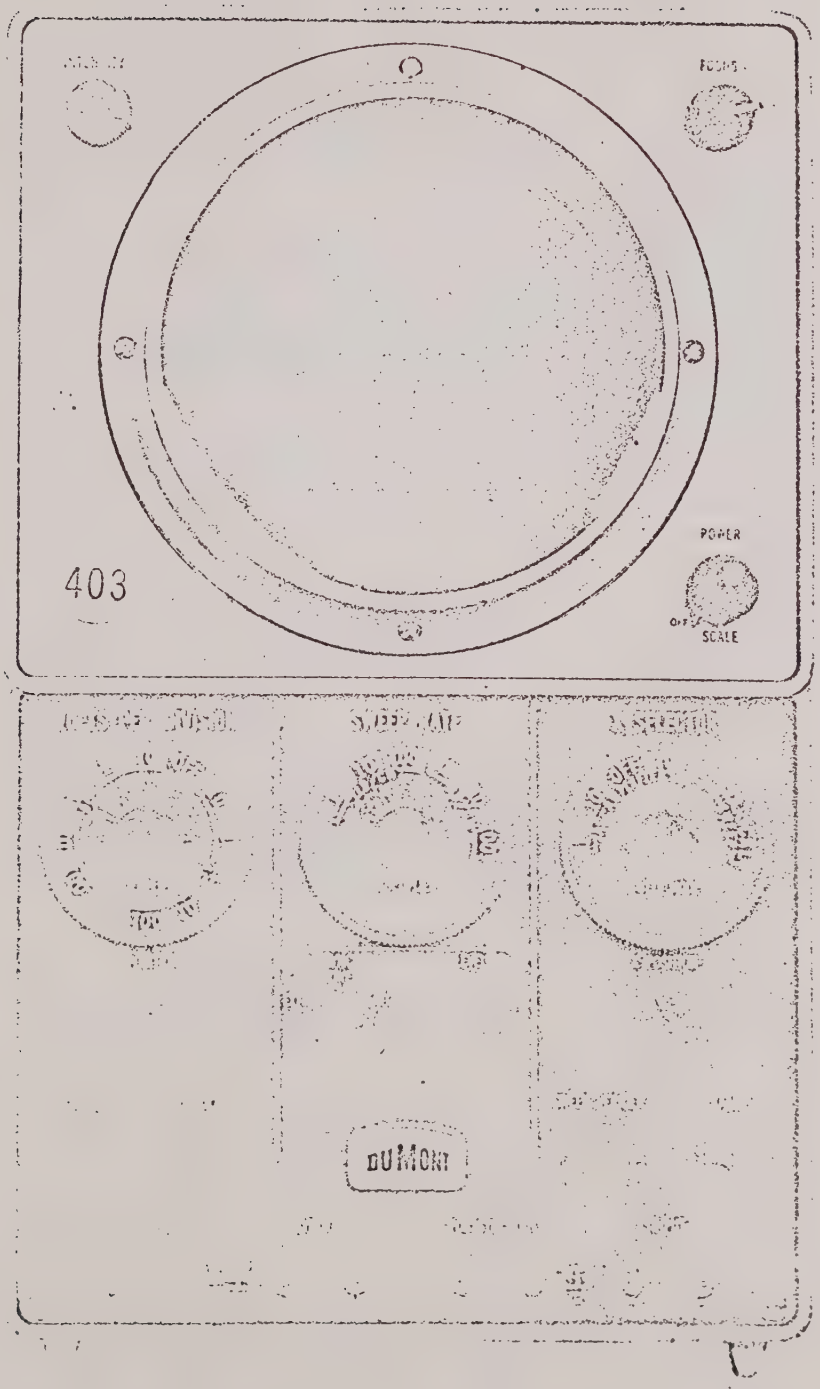


Figure 2-1. Front Panel Facilities

2-3. PRECAUTION AGAINST SCREEN BURNING

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time. Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when using the driven mode of sweep operation, with the INTENSITY turned up, and no signal input.

2-4. ENERGIZING THE EQUIPMENT

To place the instrument in operation, plug the power cord into the proper power source and rotate the POWER/SCALE control clockwise. Allow approximately 15 minutes for the instrument to warm up.

2-5. OPERATING HINTS FOR THE SWEEP CIRCUIT

a. Interpretation of Sweep Control Settings (Table 2-2)

The calibrated sweep writing rate in milliseconds or microseconds per centimeter is equal to the product of the SWEEP RATE and MULTIPLIER controls only when the X SELECTOR switch is set to CAL SWEEP. Table 2-2 lists the control settings for calibrated sweep operation.

When the MULTIPLIER control is in the VERN position, the sweep rate is continuously variable over a 10:1 (uncalibrated) range. Sweep expansion is obtained by setting the X SELECTOR switch to VAR SWEEP and adjusting the X AMP for the desired expansion up to a ratio of 5:1. Under these conditions, use of the X POSITION control enables any portion of the expanded sweep to be displayed on the screen.

b. Sweep Calibration Procedure

(1) Using 50, 60-Cycle Line Frequency

Over-all sweep calibration at the power-line frequency will normally provide a sufficiently high degree of accuracy. This is because the power-line frequency is generally held accurate to 0.5%, comparable to a finely focused spot on the screen.

The complete sweep calibration procedure is given in Maintenance, Table 4-2. However, reference to this procedure should be resorted to only if the instrument cannot be calibrated properly by means of the SWEEP CALIBRATE adjustment (right side of cabinet). When checking sweep calibration, refer to the instructions found on the inside left panel of the cabinet or to the instructions which follow:

1) Allow a minimum warm-up time of 15 minutes.
2) Set MULTIPLIER to CAL and X SELECTOR to CAL SWEEP.
3) Set SWEEP RATE to 10 MS/CM and MULTIPLIER to X1.
4) Set SYNC SELECTOR to INT and adjust SWEEP MODE for a stable pattern.

TABLE 2-2
CALIBRATED SWEEP WRITING RATES

SWEEP RATE set to	MULTIPLIER set to X1	X2	X5	X10
	Sweep rate in milliseconds per centimeter			
100 MS/CM	100	200	500	1000
10 MS/CM	10	20	50	100
1 MS/CM	1	2	5	10
	Sweep rate in microseconds per centimeter			
100 µS/CM	100	200	500	1000
10 µS/CM	10	20	50	100
1 µS/CM	1	2	5	10

TABLE 2-3
TABLE OF CALIBRATION FREQUENCIES

SWEEP RATE set to	Frequency required with MULTIPLIER set to X1	X2	X5	X10
100 MS/CM	10	—	—	—
10 MS/CM	100	50	20	10
1 MS/CM	1 Kc	500	200	100
100 µS/CM	10 Kc	5 Kc	2 Kc	1 Kc
10 µS/CM	100 Kc	50 Kc	20 Kc	10 Kc
1 µS/CM	—	—	200 Kc	100 Kc

PROCEDURE
1) Allow a minimum warm-up time of 15 minutes. 2) Set SYNC SELECTOR to INT and adjust for a stable pattern. 3) Apply the desired frequency to Y INPUT in accordance with the SWEEP RATE and MULTIPLIER settings. 4) Adjust SWEEP CALIBRATE until 10 cycles of the applied signal appears precisely in ten centimeters.

5) If necessary, set the SWEEP DURATION (see figure 4-3) to give a minimum deflection of ten centimeters.
6) For a 60-cycle line, adjust SWEEP CALIBRATE until 6 cycles of the calibration signal appears precisely in ten centimeters. All ranges will then be within the specified tolerance.
7) For a 50-cycle line, adjust SWEEP CALIBRATE until 5 cycles of the calibration signal appears precisely in ten centimeters.

(2) Using Other Calibration Frequencies (Table 2-3)

Table 2-3 lists control settings and frequencies, under which conditions, exactly 10 cycles of the applied signal appears in precisely ten centimeters. To facilitate sweep calibration, it is suggested that the applied signal be limited to frequencies between 10 cycles and 200 kilocycles. Above 200 kilocycles, synchronization difficulties may occur. Below 10 cycles, trace flickering may interfere with the calibration procedure.

c. Driven Sweep (Table 2-4)

Refer to Table 1-1, Technical Summary, for information on sync sensitivities, and to Table 2-1 for information on panel controls.

A stable pattern for practically all types of signals can be obtained by using driven sweep; its use is mandatory for viewing random or non-periodic signals or periodic signals of low duty cycle. When operating the instrument in this manner, one sweep occurs for each signal impulse. Use of the driven sweep mode of operation, in the majority of applications, is the condition under which optimum performance can be expected of this equipment.

When the instrument is set for driven sweep, the spot will be visible only during forward sweep time, provided the INTENSITY control is not set too far clockwise.

Table 2-4 lists the control settings and adjustment procedures for driven sweep operation.

d. Recurrent Sweep

In some applications it is desirable to have the sweep free-running, whether synchronized or not. To achieve this condition proceed as follows: set up the controls as indicated in Table 2-4, except that the SWEEP MODE control is adjusted until the sweep operates continuously.

One advantage of this mode of operation, is the ability of the sweep to be synchronized to high-frequency repetitive functions beyond that of driven sweep operation. Another advantage is the display of non-synchronous waveforms.

TABLE 2-4
DRIVEN SWEEP OPERATION

CONTROL	SETTING
INTENSITY & FOCUS	Approximately 1/3 CW
VOLTS PER DIVISION & MULTIPLIER	Set as determined by amplitude of signal source
X SELECTOR	CAL (or VAR) SWEEP
SYNC SELECTOR	Set as determined by signal source
SYNC AMPLITUDE	"0" (no sync)
X & Y POSITION	Center of range

PROCEDURE

1) Apply the desired signal to Y INPUT
2) Rotate SWEEP MODE clockwise to just below the threshold of free-running sweep
3) Adjust SYNC AMPLITUDE until a steady pattern appears
4) Set SWEEP RATE and MULTIPLIER controls to obtain the desired number of cycles on screen
5) Adjust INTENSITY and FOCUS controls to obtain a sharp trace of suitable brightness level
6) If necessary, make slight corrections of the SYNC AMPLITUDE and SWEEP MODE control settings to achieve optimum stability

e. Extension of Low Sweep Rates (Figure 2-2)

Provision is made for connecting external capacitors to obtain lower sweep writing rates than provided for in the instrument. For lower speed rates, proceed as follows:

CAUTION

The external capacitor terminals (see Figure 4-2) are approximately 120 volts above ground

Turn off the power and set SWEEP RATE to 50 MS/CM and MULTIPLIER to X10. Connect the capacitor to the terminals provided. The sweep rate is given by the following formula:

$$T = \frac{C + 2}{2}$$

Where: T = sweep rate in seconds per centimeter
C = additional shunt capacitance in microfarads

This formula is shown graphically in Figure 2-2.

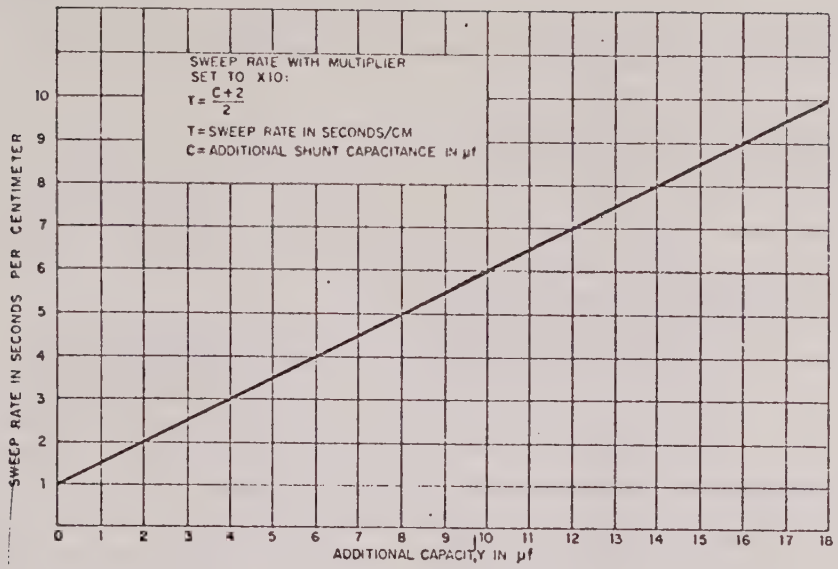

SWEEP RATE WITH MULTIPLIER SET TO X10:
T = (C+2)/2
T = SWEEP RATE IN SECONDS/CM
C = ADDITIONAL SHUNT CAPACITANCE IN µf
SWEEP RATE IN SECONDS PER CENTIMETER
ADDITIONAL CAPACITY IN µf

Figure 2-2. Additional Capacitance Versus Sweep Rate

A high-leakage resistance capacitor (in excess of 1000 megohms) of the highest possible quality such as Sprague's Styracon B is recommended. Ordinary paper capacitors have high temperature co-efficients and poor recovery characteristics. The results will depend entirely on the quality of the component. Tolerance of the capacitor should be ±1% to maintain external calibration equivalent to internal calibration.

f. Positive Sync Output

A portion of the sweep unblanking gate is picked off and coupled by a blocking capacitor to the front panel terminals marked POS SYNC OUT. The signal appears as a positive pulse and is coincident with the start of the sweep to enable synchronization of auxiliary equipment. Note: At the lower sweep rates, the POS SYNC OUT signal is differentiated by the blocking capacitor and load resistor. Thus, a positive signal coincident with the start of the sweep and a negative signal coincident with the end of the sweep are available.

g. Sync From Composite Video Signals

To facilitate synchronization of the sweep at field rates from a composite television signal, proceed as follows: Set up the controls as indicated in Table 2-4 except that SYNC SELECTOR is set to EXT. Connect a 100K-ohm resistor between the Y INPUT and SYNC IN terminals. This resistor, together with the stray capacitances will integrate the vertical serrated pulses when the composite signal is applied to Y INPUT. Adjust the SWEEP RATE and MULTIPLIER controls for a sweep duration equal to at least the duration of the vertical interval (540 microseconds).

2-6. OPERATING HINTS FOR THE HORIZONTAL AMPLIFIER

a. X Input

For those applications where it is desirable to apply external single-ended signals through the horizontal amplifier, proceed as follows: Set X SELECTOR to AMPLIFIER, AC or DC, and apply the signal to the X INPUT terminals. When the X SELECTOR switch is in the AMPLIFIER positions, the internal sweep is disconnected and the X INPUT terminals are connected to the horizontal amplifier. Attenuation of signals by ratios of 1 or 10 may be obtained.

b. X Amplifier Gated Beam Operation

When the X SELECTOR is set for external signals, the sweep circuit is not disabled unless the SWEEP MODE control is fully counterclockwise. Thus, it is possible to trigger the sweep, while viewing external signals, to superimpose the brightening gate on the trace. The duration of this gate may be adjusted by the SWEEP RATE and MULTIPLIER controls.

c. Horizontal Signal Expansion

The over-all gain of the X amplifier is varied by the X AMP control. The range of this control is such that it provides continuous expansion of the X signal or of the uncalibrated sweep (X SELECTOR set to AMPLIFIER or VAR SWEEP) up to five times full scale (50 centimeters).

2-7. OPERATING HINTS FOR THE VERTICAL AMPLIFIER

a. Balancing Procedure

(1) Y Mult Bal

When this control is properly adjusted, there will be no vertical shifting of the trace when switching through the ranges of the VOLTS PER DIVISION and MULTIPLIER controls. Adjustment is as follows:

1) Refer to Table 4-2, Service Adjustment Chart, and check out the GRID CURRENT ADJ.
2) Set the MULTIPLIER to BAL and center the trace with Y POSITION control.
3) Set MULTIPLIER to X.1 and recenter the trace with the Y MULT BAL control.
4) If necessary, repeat steps 2 and 3 until no vertical displacement of the trace is observed while switching the VOLTS PER DIVISION and MULTIPLIER controls throughout their ranges.

(2) Y Cal Adj Dc Bal

Center the trace with the X POSITION and Y POSITION controls. If the trace moves up and down as the Y CAL ADJ is rotated, the Y CAL ADJ DC BAL should be adjusted as follows:

1) Make sure the Y MULT BAL control is checked out as given in paragraph (1).
2) Set VOLTS PER DIVISION to OFF or ground Y INPUT terminal.
3) Set Y CAL ADJ fully clockwise.
4) Center the trace with Y POSITION control.
5) Rotate Y CAL ADJ fully counterclockwise and recenter the trace with the Y CAL ADJ DC BAL control (left side of chassis).
6) If necessary, repeat steps 3 through 5 until no change in vertical displacement of the trace is observed while varying Y CAL ADJ throughout its range.

Note: If Y MULT BAL is readjusted, the Y CAL ADJ DC BAL may also need readjustment.

b. Y Calibration

Amplitude measurement of the vertical signal may be made by use of the built-in voltage calibrator. The calibrator signal is available internally, and may be substituted for the vertical signal as follows:

1) Set MULTIPLIER to CAL.
2) Adjust Y CAL ADJ to give full scale deflection (three inches). Do not touch this adjustment after it has been set up for amplitude measurement; if moved, repeat step 1.
3) Remove the calibrator pattern by setting the MULTIPLIER to X.1, X.5, X1, X2 or X5 position as determined by the amplitude of the signal source.

The vertical amplifier now functions as a voltmeter having a major scale division sensitivity determined by the product of the VOLTS PER DIVISION and MULTIPLIER control settings.

c. Y Input

(1) Single-ended Input

Signals to be observed are connected to the vertical channel through the Y INPUT terminal and ground. The VOLTS PER DIVISION switch permits capacitive or direct coupling of the signal to the compensated attenuator. The terminals for direct connection to the deflection plates are accessible at the rear of the cabinet. (See paragraph 2-8 for details.)

(2) Use of Balanced Input

For balanced input, remove the link from the normally grounded Y INPUT terminal. The VOLTS PER DIVISION switch must be set to the .001 or .01 DC position. Refer to Table 1-1, Technical Summary, for information on limits of common mode signal.

One of the features of the balanced-input circuit is the differential action of the amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal, while at the same time passing and amplifying the balanced-input signal. Thus, if there is any pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input amplifier circuit.

2-8. DIRECT CONNECTION TO DEFLECTION PLATES

a. General

When applying signals to deflection plates, the highest-frequency signal that can be observed is not limited by the response of the built-in amplifiers but is dependent upon the input capacitance to the deflection plate terminals and/or transit time of the electrons between the deflection plates. When the impedance of the signal source is low, transit time is the only consideration. It should be remembered, however, that no amplification or attenuation is provided on direct input. See Table 1-1 for deflection sensitivities.

b. Making Proper Connections

CAUTION

Before making connections, shut off power

Direct connection to the deflection plates is made as follows:

1) Disconnect the appropriate deflection plate links from their terminals (rear of cabinet).
2) Apply the signal to D1 and D2 for direct horizontal input; to D3 and D4 for direct vertical input.
3) To avoid any possibility of cross-coupling effects, the VOLTS PER DIVISION and/or X SELECTOR should be switched to OFF.

Note: For best focus, an average dc potential of 250 volts above ground must be preserved on both pairs of deflection plates. To preserve this average dc potential when the source impedance is doubtful, it is recommended that blocking capacitors be inserted in series with each signal lead before direct connection is made. These capacitors will (1) minimize the effect of the dc deflection plate voltages on the driving source and (2) minimize the effect of the driving source impedance on the positioning voltages.

2-9. MAKING RISE TIME MEASUREMENTS

Application of signals from an external time calibrator will facilitate pulse rise-time measurements. When making such measurements, the one factor which must be borne in mind for most accurate quantitative results is the pulse response characteristic of the vertical amplifier. This characteristic is related to the observed pulse rise time and the actual pulse rise time in the following manner:

$$t_p = \sqrt{(t_o)^2 - (t_a)^2}$$

Where: t_p = actual pulse rise time in microseconds
t_o = observed rise time of pulse in microseconds
t_a = amplifier rise time in microseconds

Once the amplifier rise time is known (see Table 1-1), the rise time of any pulse may be calculated.

2-10. INTENSITY MODULATION

Refer to Table 1-1, Technical Summary, for intensity modulation data. For intensity modulation of the trace, shut off the power and apply the signal between the Z INPUT terminal (rear panel) and ground.

SECTION 3
THEORY OF OPERATION

3-1. GENERAL (See Figure 3-1)

To simplify circuit analysis, the instrument can be divided into five basic sections as follows: (1) Vertical Deflection Amplifier; (2) Horizontal Deflection Amplifier; (3) Sync and Sweep Circuits; (4) CRT, Beam Gate, and RF Supply; and (5) Heater and Low-voltage Supply. It is recommended that the schematics in Section 5 of this manual be referred to in following the circuit description. For information on service adjustments, refer to Maintenance, Table 4-2.

3-2. VERTICAL DEFLECTION AMPLIFIER

a. Volts Per Division and Multiplier

The VOLTS PER DIVISION control consist of three RC compensated attenuators. These attenuators present a constant impedance to the circuit under test regardless of the attenuation selected. The OFF position of this switch removes the input signal from the attenuator and grounds the grid of V101B.

Four positions of the MULTIPLIER control consist of shunt resistors which are switched into the amplifier to vary its gain per knob markings. Thus, the sensitivity of the amplifier is determined by the product of the VOLTS PER DIVISION and MULTIPLIER control settings.

To facilitate adjustment of the Y MULT BAL control, the plates of V102A and V102B are tied directly together in the BAL position of the MULTIPLIER switch. The current in both halves of the cascode circuit is then adjusted by the Y MULT BAL control such that the plate-to-plate voltage across V102 equals zero. In this way, impedance changes across these plates (caused by switching the MULTIPLIER resistors) are not manifested as undesired voltage changes. For those applications where an optimum common mode rejection is desired, an auxiliary balance entitled DYNAMIC BAL is provided. It is used in conjunction with the Y MULT BAL control to obtain common mode rejection up to 1000:1. See Section 4, Maintenance, for further information.

When the MULTIPLIER is set to CAL, the over-all sensitivity of the vertical amplifier is adjusted by Y CAL ADJ to match the voltage of the internal calibration signal.

b. Deflection Amplifiers

V101 and V102 are connected in a cascode type circuit to obtain the equivalent performance of pentodes. The advantages of this arrangement using the Type 6J6 are:

1) Minimum differences in change of transconductance of both halves of the tube due to heater-potential variations (6J6 has a common cathode with a single heater).
2) High input impedance.
3) Low gas currents.
4) Two extra grids are available to facilitate dc balancing of the input stages.

The normally grounded grid of V101A is brought out to a front-panel binding post in order that balanced input operation may be obtained. For use of this feature, see Section 2, Operation. R109 and R111 in series with the grids of V101 protect the input circuit from damage due to excessive input voltages. Shunting capacitors C109 and C112 provide frequency compensation.

Undesirable negative voltages are developed at the grids of V101 due to gas currents. The grid load resistors are returned to a positive potential, which is controlled by the GRID CURRENT ADJ to cancel this negative potential.

V103 through V106 are connected as cathode-coupled dc amplifiers to provide push-pull signals for application to the vertical deflection plates.

3-3. HORIZONTAL DEFLECTION AMPLIFIER

a. X Selector

The X SELECTOR switch provides for the selection of internal or external single-ended signals for horizontal deflection. The internal signal is obtained from the linear sweep circuit discussed elsewhere in this section. When X SELECTOR is set to AMPLIFIER, the internal sweep is disconnected and the X INPUT terminals are connected to the input cathode follower, V201. Attenuation of external ac or dc signals by factors of 1 or 10 may be obtained. The OFF position of this switch removes the input signal from the attenuator and grounds the grid of V201.

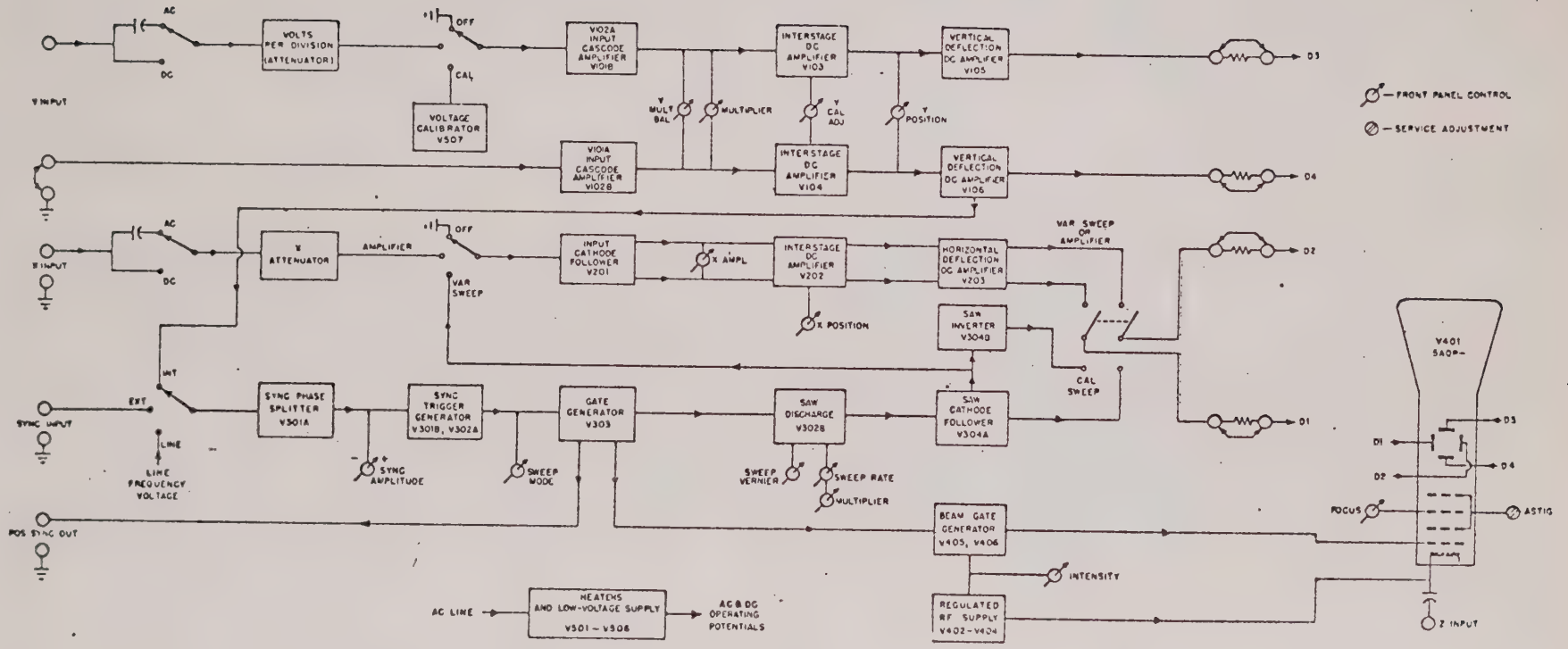


Figure 3-1. Over-All Functional Block Diagram Type 403, 403-R Oscilloscope

b. Deflection Amplifiers

V202 and V203 are connected as cathode-coupled dc amplifiers to provide push-pull signals for application to the horizontal deflection plates. The over-all gain of the X amplifier is controlled by the X AMP control. The range of this control is such that it provides continuous expansion of the X INPUT or of the VAR SWEEP signal up to five times full scale. The positioning system provided is such that with a horizontal deflection equivalent to five times full scale, any portion of this deflection may be centered on the screen by the X POSITION control.

3-4. SYNC AND SWEEP CIRCUITS
(See schematic for waveforms)

a. Sync Circuit

The SYNC SELECTOR switch provides selection of the synchronizing signal: INT (signal obtained from a tap on the plate lead of V106 in the vertical channel), LINE frequency, or EXTernal (signal obtained from an external source). V301A functions as a sync phase splitter. The SYNC AMPLITUDE control enables the operator to select the desired amplitude and polarity of the sync voltage. Following this control is the sync trigger generator, V301A and V302A. The bias level of this stage is established by the +120V ADJ and TRIGGER service adjustments.

The sync trigger generator operates as follows: under stable conditions, V301B is fully conducting and V302A is at cutoff. V301B is initiated by waveform **B** applied to its grid, resulting in a sudden transition of V301B from full conduction to cutoff yielding waveform **C**. Conversely, V302A is suddenly fully conductive, resulting in a fast negative step, waveform **D**, at its plate. Waveform **D** is coupled to the cathode of the gate generator, V303, through a series-triggering crystal diode, CR301. This diode serves as a sync lockout stage during the forward sweep time as follows: when V303 is triggered, its cathode voltage drops approximately eight volts. Since the plate of CR301 is connected to this point, it becomes automatically non-conductive during the forward sweep time, thereby preventing the passage of unwanted sync signals.

b. Sweep Circuit

(1) Gate Generator

Depending on the setting of the SWEEP MODE control, V303 operates as a bistable or a free-running multivibrator. In the bistable condition, the SWEEP MODE control is set such that, initially, V303A is at cutoff and V303B is fully conducting. Waveforms **E**, **F**, and **G** are developed when V303 is initiated. Waveform **G** is coupled to the POS SYNC OUT terminal and is coincident with the start of the sweep to enable synchronization of auxiliary equipment. This waveform is also used to initiate the beam gate generator, V405, which provides a brightening voltage during forward sweep time.

(2) Positive Saw Generation

The negative gate output, waveform **E**, is coupled to the saw discharge tube, V302B, which is normally conducting and maintaining the sweep rate capacitor in a discharged state. Waveform **E** turns off V302B and allows the voltage at its plate to rise at a rate determined by the product of R and C as selected by the SWEEP RATE and MULTIPLIER controls. The resultant sawtooth voltage is coupled to the saw cathode follower, V304A.

The voltage at the cathode of V304A is fed back to the grid of the nonconducting gate tube, V303B via the SWEEP DURATION service adjustment. This restores the gate generator to its initial operating conditions (when the sawtooth voltage reaches a predetermined level) thus terminating the sweep. For driven sweep operation, the beam will sweep across the screen again only upon the application of another negative signal from the sync trigger generator to V303.

A high degree of linearity is achieved by causing the dc voltage of the charging source to rise at saw rate through use of a gas tube, V305, coupled to the sweep charging resistors. This essentially provides a constant-current charging source for the sweep capacitor. Since the charge across any capacitor is directly proportional to the current flowing into it, a constant (unvarying) current results in a uniform increase in charge or a linear sawtooth waveform.

(3) Calibrated Sweep

The calibrated sweep writing rate in milliseconds or microseconds per centimeter is equal to the product of the SWEEP RATE and MULTIPLIER controls only when the X SELECTOR switch is set to CAL SWEEP.

Waveform **H** from the saw cathode follower, V304A, is directly coupled to horizontal deflection plate D2 through a saw level stage, V305. Simultaneously, output of the same polarity and of reduced amplitude is applied to the grid of the saw inverter, V304B. Waveform **I** at the plate of V304B is opposite phase but of the same amplitude as waveform **H**, is coupled to the other horizontal deflection plate, D1.

Positioning of the high level calibrated sweep is accomplished by coupling waveform **I** through two

neon bulbs, E301 and E302. These bulbs provide two basic dc levels of negative saw without attenuation. The highest level is established at the plate of V301B and the second level is about 120 volts below this point. The X POSITION control, R216B, is shunted across these bulbs with the control arm connected to deflection plate D1. Capacitor C342 serves to prevent variation in high-frequency response with changes in the setting of the X POSITION control.

(4) Variable Sweep

When the X SELECTOR switch is set to VAR SWEEP, the high level sweep is connected directly to the horizontal deflection plates. In the VAR SWEEP position, the high level saw is disconnected from the horizontal plates and a portion of the positive saw is coupled to the input of the horizontal cathode follower, V201. The sweep is then converted to push-pull output and may be expanded up to five times full scale by the horizontal deflection amplifiers V202 and V203, before application to the deflection plates.

3-5. CRT, BEAM GATE, AND RF SUPPLY

a. Cathode-ray Tube

A Type 5AQP— cathode-ray tube is used, operating at a total accelerating potential of 2500 volts. Excellent spot size, focus, and pattern brilliance are features of this mono-accelerator tube.

b. Focus

The setting of the FOCUS control establishes the relative potential difference between the focus anode and cathode of V401. The vertical deflection plates, D3 and D4, and the horizontal deflection plates, D1 and D2, operate at an average dc potential of about 250 volts above ground. To avoid beam distortion, the second anode must operate at approximately the same dc potential. The second anode voltage is derived from the arm of the ASTIGmatism service adjustment, R401.

c. Intensity Modulation

For intensity modulation of the beam, positive (blanking) or negative (brightening) signals may be applied to the Z INPUT terminal through coupling capacitors, to the cathode of V401. See Table 1-1 for additional information.

d. Beam Gate and Intensity Circuits

(1) General Description

The primary functions of the beam gate, V405, are: (1) to provide return trace blanking for recurrent sweep operation, and (2) when driven sweep operation is desired, to automatically turn on the cathode-ray tube beam for the duration of the forward sweep interval and then turn it off automatically at the end of this interval. This latter feature prevents film fogging and/or screen burning prior to the initiation of driven sweep.

A basic function of the beam gate generator is to transfer the brightening gate from a low dc level (about 300 volts) to the high dc level of the cathode-ray tube grid (negative high voltage).

These functions are resolved by using a conventional bistable multivibrator, V405. The mean dc level of this stage is equal to the average level of the cathode-ray tube accelerating potential. Thus, only short pulses are needed to trigger V405 on or off, enabling the use of a much smaller coupling capacitor.

(2) Detailed Description

Under stable conditions, the constants of the beam gate circuit are such that V405A is at cutoff, and V405B is fully conducting. When the sweep starts, the positive leading edge of the gate coupled from the plate of V303B is applied to the grid (pin 2) of V405A, turning on this stage and turning off V405B. Thus, the grid of the cathode-ray tube is held above cutoff for the duration of the forward sweep time. V405 is restored to its original condition by the negative trailing edge of the gate.

Plate voltages for the beam gate circuit are derived from a separate power supply which is completely isolated from ground and is tied into the —HV supply via the INTENSITY control.

(3) Intensity

Adjustment of the INTENSITY control varies the grid bias of the cathode-ray tube by changing the entire dc level of the isolated supply with respect to the —HV supply. When the INTENSITY control is turned fully counterclockwise, and V405A is fully conducting, the grid of V401 is 100 volts more negative than its cathode, thus extinguishing the cathode-ray tube beam.

e. Regulated RF Supply

(1) General Description

Operating potentials for the proper intensity and focusing of the cathode-ray tube beam are derived from the regulated rf supply. Regulation is accomplished by sampling a portion of the rectified output, and feeding a correcting signal back through V403 to the screen grid of V404.

(2) Detailed Description

The rf power oscillator, V404, operating in the vicinity of 150-200 Kc, develops an ac potential across the primary of T401. The amplitude of this voltage is proportional to the screen voltage applied to V404. Hence a change in the rectified output can be corrected by an appropriate (increase or decrease) change in V404 screen potential. For example, a decrease in the rectified output would result in an error voltage fed back to a two stage direct-coupled control amplifier, V403A and V403B. These stages supply the correction signal which is coupled to the screen of V404. The screen voltage is increased, which increases the ac output voltage across T401, thus compensating for the decrease in output voltage mentioned earlier.

The advantages of an rf supply system of generating CRT accelerating potentials, compared to that of conventional "brute force," low-frequency systems are:

(1) Relative ease of incorporating control amplifiers to maintain constant, effectively low output impedance.

(2) Elimination of high-voltage, high-capacitance filters which are expensive and bulky.

(3) Sharp reduction in shock hazard due to the smaller capacitors used in the filter system.

3-6. HEATERS AND LOW-VOLTAGE SUPPLY

V504 is connected in a conventional full-wave rectifier circuit. The rectified output is capacitively filtered by C505 and C506. These capacitors are shunted by resistors R512 and R513 to equalize the voltage across them.

Regulated output, obtained from conventional voltage regulator circuitry, of +400, +185, +150, +120, and −85 volts are available. DC regulated heater voltage is provided for the vertical input cascode and interstage amplifiers, V101-V104. This voltage is derived from a full-wave bridge rectifier, CR502, the output of which is coupled to a 0.9 ampere and a 0.45 ampere series heater regulators RT502 and RT501.

SECTION 4
MAINTENANCE

WARNING

OBSERVE THE FOLLOWING PRECAUTIONS WHEN NECESSARY TO ENERGIZE THE EQUIPMENT WITH THE CABINET REMOVED:

1) Never work alone.
2) Make sure the chassis is properly grounded.
3) Remove power cord before changing any tubes.
4) Before touching any components, short the terminals to remove any possible charge that may remain after turning off the power.

4-1. GAINING ACCESS TO THE CHASSIS

The unit is enclosed in a cabinet which is composed of four removable panels (top, bottom, left, and right sides). To gain access to the chassis, remove the two screws securing the top edge of each side panel and loosen the bottom edge screws. After the side panels are removed, the top and bottom panels may be taken off if desired. To take off the bottom panel, remove the two flat head screws located on the fold-over on each side. The top panel is similarly removed. Note: the top panel will not normally require removal.

4-2. SERVICE ADJUSTMENTS

Do not touch any service adjustments unless tests clearly indicate the need to do so. Such adjustments should not be attempted without a complete understanding of the proper procedure. Consult Tables 4-1 and 4-2 for special instructions. The procedures given in Table 4-2 are based on the assumption that no tubes or components are faulty. Whenever these conditions are not met, see paragraph 4-3, Servicing Hints.

4-3. SERVICING HINTS

In the event of improper equipment performance, the following suggestions are recommended.

1) Note that all tube heaters are lit.
2) Check all supply voltages; includes the ac power line, +400, +185, +150, +120, and the −85-volt levels.
3) *Do not tamper* with any of the service adjustments as this will only complicate servicing.
4) The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit causing the trouble. A separate schematic for each basic section of the instrument is provided as follows:
   a. Vertical Deflection Amplifier
   b. Horizontal Deflection Amplifier
   c. Sync and Sweep Circuits
   d. CRT, Beam Gate, and RF Supply
   e. Heaters and Low-voltage Supply
5) Localizing the trouble is made easier by use of a test probe coupled to a cathode-ray oscilloscope. Key waveforms are shown on the Sync and Sweep schematic.
6) When a point is reached where normal performance ceases abruptly, a replacement tube should be tried before attempting any other tests. In some cases, a second new tube must be tried.
7) Replacement of certain tubes may require resetting of one or more service adjustments. Consult Table 4-3. For optimum stability, the new tube should be allowed a warmup time of at least 10 minutes before making any final service adjustments.
8) As a further aid to servicing, see Table 4-4, Servicing Hint Chart.
9) If after tube replacement the trouble persists, replace the original tube in its socket and check for proper voltage and resistance per Tables 4-5 and 4-6.
10) Maintain a high quality of workmanship. Use a clean bench and soldering iron; keep solder joints smooth and bright; do not overheat any component while soldering.

4-4. CATHODE-RAY TUBE REPLACEMENT

CAUTION

The cathode-ray tube should be handled with great care to prevent breakage and/or serious personal injury from flying glass. Do not employ force at any time. As an added precaution, it is advisable to wear safety goggles and gloves.

The following step-by-step procedure is suggested for replacing the cathode-ray tube:

1) Turn off the power.

2) Remove bezel, held by four screws at front panel.
3) Remove the cathode-ray tube socket.
4) Loosen the cathode-ray tube clamp via screw through the access hole in the magnetic shield.
5) Remove tube through front panel opening.
6) Remove the rubber sleeve from the old tube and install it on the new tube.
7) Install new tube through front panel opening, and replace the bezel.
8) Replace the tube socket.
9) Apply power and check the sweep; if not horizontal, rotate the tube by the insulated handle as required.
10) Tighten the cathode-ray tube clamp securely to prevent rotation in handling. It is not possible to damage the tube in tightening due to the protection provided by the rubber sleeve.

4-5. ILLUMINATED SCALE LAMP AND PILOT LAMP REPLACEMENT

a. Defective scale lamps are removed as follows:
   1) Turn off power and remove the side panels.
   2) Remove the appropriate lamp assembly located on the rear side of the front panel by depressing the spring clip. The defective bulb may then be removed and replaced.

b. Defective pilot lamp is removed as follows:
   1) Turn off power and remove bottom panel.
   2) With the unit upside down, replace the defective bulb.

TABLE 4-1
TEST EQUIPMENT REQUIRED FOR SERVICE ADJUSTMENTS

REF. No.	DESCRIPTION	RANGE OR CHARACTERISTICS
(1)	Volt-ohmmeter	20K ohms/volt Test Meter or Vacuum Tube Voltmeter
(2)	Square-wave Generator	1 Kc to 100 Kc
(3)	Voltage Calibrator	0.1 volt to 100 volts; ±1%
(4)	Sine-wave Generator	1 Kc to 100 Kc; accuracy ±1%

TABLE 4-2
SERVICE ADJUSTMENT CHART

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT.

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
POWER SUPPLIES AND CRT		
+400V ADJ (R505)	(1)	Connect a voltmeter between pin 3 or 6 of V502 and ground. Adjust R505 for 400 volts
—HV ADJ (R405)	(1)	Connect a voltmeter from center terminal of INTENSITY control to center terminal of the ASTIG adjustment. Adjust R405 for —2500 volts
ASTIG (R401)	—	R401 is used in conjunction with the FOCUS control for adjusting uniformity of trace 1. Obtain several cycles of the internal calibration signal on the screen 2. Adjust R401 simultaneously with the FOCUS control for the best focus 3. In order to maintain the over-all sweep calibration, recheck the —HV ADJ . .
VERTICAL DEFLECTION AMPLIFIER		
Y LIN (R145)	—	R145 is used to select the proper operating point for V105 and V106 so that optimum vertical linearity may be obtained. 1. Apply a signal to Y INPUT and adjust for three divisions of vertical deflection 2. Position the pattern to the upper and lower limits of the screen and note any change in pattern size 3. The pattern size should not vary by more than ±2%. (0.06 division). If this figure is exceeded, adjust R145 until a minimum change in size occurs 4. If satisfactory adjustment cannot be achieved, replace V105 and/or V106 5. After R145 is properly adjusted, recheck the ASTIG adjustment
VOLTS PER DIVISION Compensation capacitors	(2)	Apply a 10 Kc square wave signal to Y INPUT and adjust the capacitors listed to obtain flat-top square wave VOLTS PER DIVISION set to — Adjust .1 — C102 1 — C104 10 — C106

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
VERTICAL DEFLECTION AMPLIFIER		
GRID CURRENT ADJ (R107)	—	R107 is used to cancel the negative voltage developed at the grids of V101 due to gases and leakage currents 1. Ground the normally ungrounded terminal of Y INPUT 2. Set MULTIPLIER to X.1 and VOLTS PER DIVISION to .01 AC 3. Adjust R107 until no depositioning of the trace occurs when the VOLTS PER DIVISION control is switched from .01 to .1 AC. Inability to properly make this adjustment indicates excessive gas and leakage current in V101, which should be replaced 4. Refer to Section 2, Operation, and adjust the Y MULT BAL and Y CAL ADJ DC BAL controls
DYNAMIC BAL (R128)	(4)	R128 is used to adjust the vertical deflection amplifier for optimum common mode rejection 1. Connect both Y INPUT terminals together and set front-panel controls for maximum input sensitivity 2. Apply a 1 Kc sine wave signal of about 0.2 volt rms to Y INPUT; note the resultant deflection amplitude 3. Turn R128 clockwise † about 10° and bring the trace back on the screen with the Y MULT BAL control. A reduction in deflection amplitude should be noted 4. Continue turning R128 clockwise while correcting with the Y MULT BAL control until minimum possible deflection is reached †NOTE: If clockwise rotation of R128 causes an increase rather than a decrease in deflection, turn R128 counterclockwise in steps 3 and 4
CAL VOLTS (R524)	(3)	R524 is used to set the output of the voltage calibrator to 0.5 volt 1. Set VOLTS PER DIVISION to 1 DC and MULTIPLIER to X.1 2. Apply a 0.10 volt signal from an external voltage calibrator to Y INPUT 3. Advance Y CAL ADJ control for exactly full scale deflection 4. Set MULTIPLIER to CAL and adjust R524 to give the same full scale deflection
SYNC AND SWEEP CIRCUITS		
TRIGGER (R307) and +120V ADJ (R515)	—	R307 is used to control the threshold bias of V301 1. Set the +120V ADJ so that the SWEEP MODE control range is approximately centered. This range is established by (1), the point where the synchronized driven sweep cuts off, and (2), the threshold of recurrent sweep with no sync applied. 2. Obtain 2 or 3 cycles of calibration waveform with the SYNC AMPLITUDE set fully clockwise and the SWEEP MODE set for optimum stability.

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
SYNC AND SWEEP CIRCUITS		
		3. Slowly reduce the SYNC AMPLITUDE and note that the sweep starts higher and higher on the leading edge of the waveform until it reaches the flat top, at which point the sweep stops. 4. During the operation of 3 above, gradually turn the TRIGGER clockwise until the point where the sweep becomes jittery and unstable when the starting point of the sweep is at the left edge of the calibration pulse flat top. 5. Reduce the TRIGGER slightly (about 2° or 3°) so that the sweep is stable for all settings of the SYNC AMPLITUDE control and stops abruptly as the control is reduced to zero.
SWEEP DURATION (R323)	—	R323 is used to control sweep length 1. Set up sweep controls for calibrated sweep 2. Adjust R323 for a sweep length of 10 centimeters (—0 or +1 centimeter) 3. In the event that sweep length is less than 10 centimeters with R323 set fully clockwise, turn the +120V ADJ slightly clockwise to correct the sweep length
Sweep Calibration Trimmers (R344, C312 & C313)	(4)	R344 is used for adjusting the over-all sweep writing rates. C312 and C313 are used for adjusting the upper and lower range of the MULTIPLIER control 1. Allow a minimum warm-up time of 15 minutes 2. Recheck the —HV ADJ and ASTIG adjustments 3. Set the adjustments listed in the table below until 10 cycles of the applied signal appears precisely in 10 centimeters NOTE: Adjustments must be made in the sequence given
HORIZONTAL DEFLECTION AMPLIFIER		
X DC BAL (R211)	—	R211 is used to set the cathode-to-cathode voltage of V201 so that both ends of the X AMP control are at the same dc potential 1. Set X SELECTOR to OFF 2. Rotate X AMP fully counterclockwise 3. Center the spot with X POSITION control 4. Rotate X AMP fully clockwise and recenter the spot with R211 5. If necessary, repeat steps 3 through 5 until no change in horizontal positioning of the spot is observed while varying X AMP throughout its range
SAW DC LEVEL (R206)	—	R206 is used to establish the average dc level of the saw at zero potential

SWEEP RATE set to	MULTIPLIER set to	Frequency required	Adjust
1 MS/CM	X1	1 Kc	R344
1 μS/CM	X10	100 Kc	C312
10 μS/CM	X1	100 Kc	C313

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Continued)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
		HORIZONTAL DEFLECTION AMPLIFIER
		1. Set MULTIPLIER to CAL and X SELECTOR to VAR SWEEP 2. Adjust appropriate controls to obtain a stable pattern of about 10 cycles 3. Adjust R206 until pattern expands equally about center of trace as X AMP control is varied NOTE: Proper adjustment of R206 is dependent to some extent on the X LIN adjustment. Hence, it may be necessary to alternate between these two adjustments in order to obtain the proper results
X LIN (R218) and Trimmer (C204)	(4)	R218 is used to select the proper operating point for V202 so that optimum horizonal linearity may be obtained 1. Obtain a full scale stable pattern of about 5 cycles of the calibrator waveform 2. Adjust R218 to satisfy the following conditions: a. The Y deflection sensitivity does not change more than 1% (±0.1 division) when X SELECTOR is switched from SWEEP CAL to SWEEP VAR b. No obvious distortion appears on any expanded portion of the fully exponded sweep 3. Set SWEEP RATE to 1 μS/CM, MULTIPLIER to X1, and X SELECTOR to VAR SWEEP 4. Obtain a stable sine wave display with the frequency set such that a large number of cycles appears on the screen 5. Adjust C204 for optimum linearity at the left edge of this display
X SELECTOR Compensation Capacitor (C202)	(2)	Apply a 10 Kc square wave to X INPUT. Proper adjustment of C202 is obtained when the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus

* Number shown ( ) corresponds to reference number of test equipment in Table 4-1

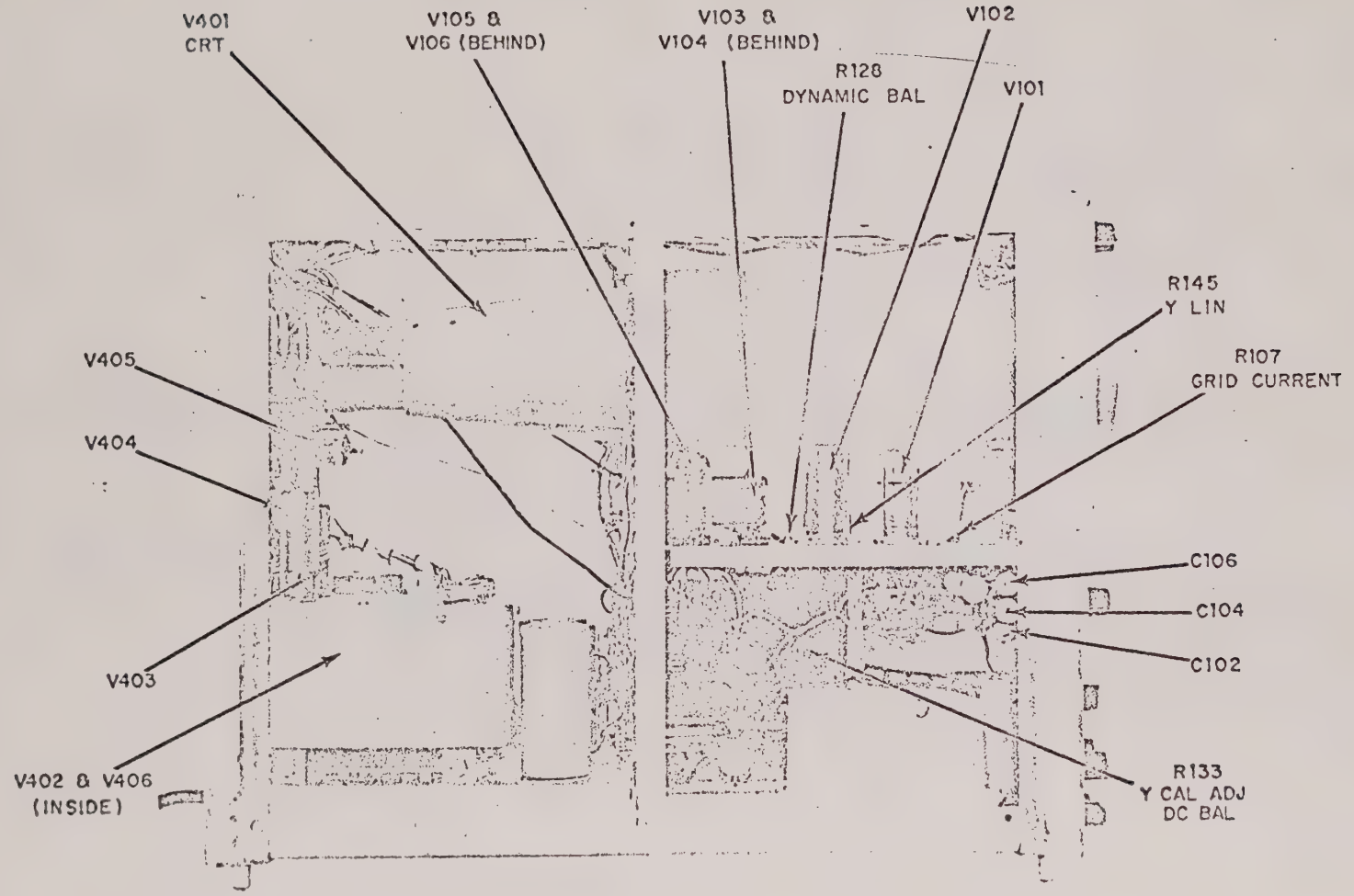


Figure 4-1. Service Adjustments and Tube Locations—Left Side View

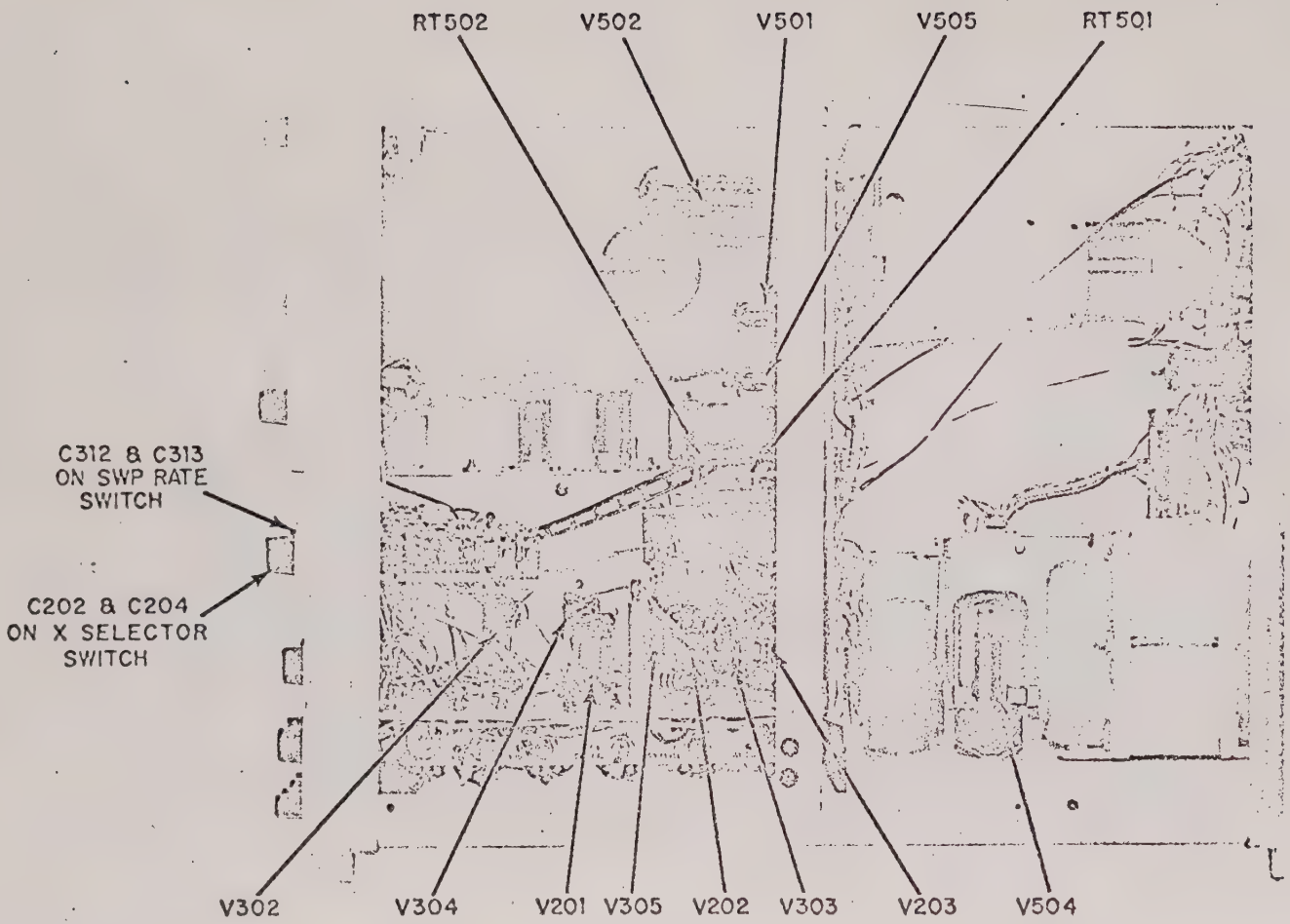


Figure 4-2. Service Adjustments and Tube Locations—Right Side View

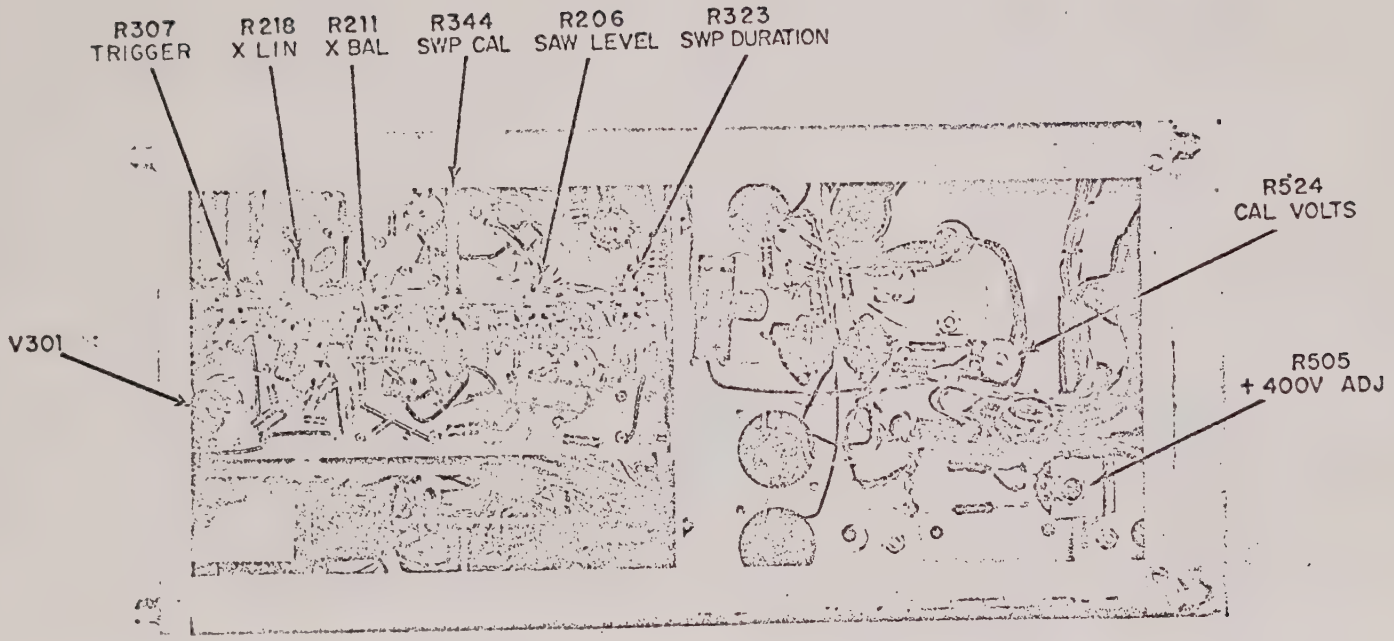


Figure 4-3. Service Adjustments and Tube Locations—Bottom View

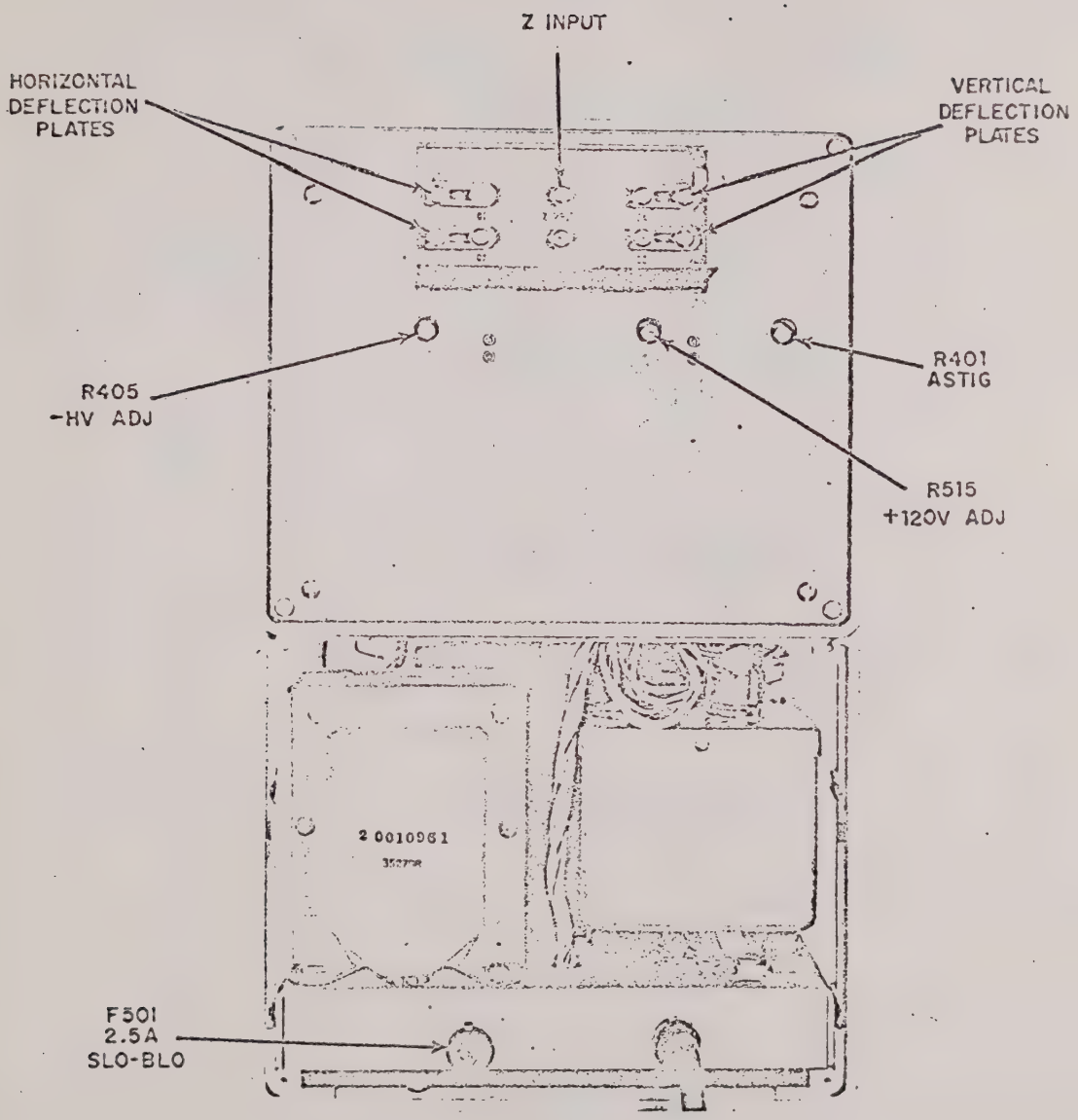


Figure 4-4. Service Adjustments and Tube Locations—Rear View

TABLE 4-3
ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
VERTICAL DEFLECTION AMPLIFIER		
V101	6J6-Y	GRID CURRENT ADJ (R107) and VOLTS PER DIVISION Capacitors (C102, C104 & C106)
V102	12AU7-R	None
V103 & V104	12AU6	Y CAL ADJ DC BAL (R133)
V105 & V106	6CL6	Y LIN (R145)
HORIZONTAL DEFLECTION AMPLIFIER		
V201	12AU7-Y	X DC BAL (R211) and X LIN (R218)
V202	12AU7-Y	X LIN (R218)
V203	12AV7-R	None
SYNC AND SWEEP CIRCUITS		
V301 & V302	12AT7	TRIGGER (R307) and +120V ADJ (R515)
V303	6U8A	TRIGGER (R307) and +120V ADJ (R515)
V304	12AT7	SWEEP CALIBRATE (R344), C312 & C313
V305	OG3	SWEEP CALIBRATE (R344), C312 & C313
CRT, BEAM GATE, AND RF SUPPLY		
V401	5AQP-	SWEEP CALIBRATE (R344) and ASTIG (R401)
V402	1X2-A	—HV ADJ (R405) and SWEEP CALIBRATE (R344)
V403	12AU7-R	See V402
V404	6AQ5A	See V402
V405	12AU7-R	See V402
V406	6AL5	See V402
HEATERS AND LOW-VOLTAGE SUPPLY		
V501	6U8A	+400V ADJ (R505)
V502	6AS7-GA	+400V ADJ (R505)
V503	OA2	+400V ADJ (R505)
V504	5V4-GA	None
V505	6U8A	+120V ADJ (R515)
V506	OG3	None
V507	6AL5	CAL VOLTS (R524)

TABLE 4-4
SERVICING HINT CHART

NOTES: 1. This chart tabulates the following information:
a. Symptoms of tube failure
b. Symptoms arising from misalignment of service adjustments
2. Some of the symptoms indicated in this chart might be caused by failure of some component associated with the circuit under analysis
3. See Sync and Sweep Schematic for waveform data

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
VERTICAL DEFLECTION AMPLIFIER	
1a. No vertical deflection	1a. V101 to V106
2a. Vertical displacement of trace noted when switching VOLTS PER DIVISION control from .01 to .1 AC	2a. GRID CURRENT ADJ (R107)
3a. Vertical shifting of trace noted when switching through ranges of the VOLTS PER DIVISION and MULTIPLIER controls	3a. Y MULT BAL (R115) See Section 2, Operation
4a. VOLTS PER DIVISION is set to OFF; trace shifts vertically with changes in setting of Y CAL ADJ	4a. Y CAL ADJ DC BAL (R133) See Section 2, Operation
5a. Size of pattern changes as it is positioned vertically on the screen	5a. Y LIN (R145)
6a. Common mode rejection ratio is lower than normal	6a. DYNAMIC BAL (R128)
HORIZONTAL DEFLECTION AMPLIFIER	
1b. No horizontal deflection; internal sweep circuit is normal	1b. V201 to V203
2b. X SELECTOR is set to OFF; trace shifts horizontally with changes in setting of X AMP control	2b. X DC BAL (R211)
3b. Sweep fails to expand equally in both directions as X AMP control is advanced	3b. SAW DC LEVEL (R206)
4b. Size of pattern is distorted when X AMP control is rotated fully clockwise	4b. X LIN (R218)
SYNC AND SWEEP CIRCUITS	
1c. No sync; satisfactory waveform at "A," nothing at "B"	1c. V301A
2c. No sync; satisfactory waveform at "B," improper waveforms at "C" and "D"	2c. V301B, V302A, and/or TRIGGER (R307)
3c. No sync; satisfactory waveforms at "C" and "D"; nothing at "E"	3c. Series triggering crystal diode, CR301
4c. No sweep; X SELECTOR set to CAL SWEEP	4c. V302B, V303, and V304; check waveforms "E" through "I"
5c. No sweep; X SELECTOR set to VAR SWEEP	5c. See 1b
6c. X SELECTOR set to CAL SWEEP; sweep length is less than 10 divisions	6c. SWEEP DURATION (R323)
7c. Approximately one-half of sweep trace is missing; SWEEP MODE is set fully clockwise	7c. V304B
8c. Unstable sweep at low sweep rates	8c. E301 and E302
9c. Over-all sweep rates are out of calibration	9c. SWEEP CALIBRATE (R344) See Section 2, Operation

TABLE 4-4. SERVICING HINT CHART (Continued)

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
CRT, BEAM GATE, AND RF SUPPLY	
1d. No spot on cathode-ray tube screen	1d. V401 and V402
2d. Poor high-voltage regulation	2d. V403 and V404
3d. Bright spot at left side of screen; visible return trace	3d. V405 and V406
4d. Non-uniform focused pattern as it is positioned over the screen	4d. ASTIG (R401)
5d. —HV output is too high or too low	5d. —HV ADJ (R405)
HEATERS AND LOW-VOLTAGE SUPPLY	
1e. Poor regulation: +185-volt supply	1e. V501A
2e. Poor regulation: +400-volt supply	2e. V501B, V502, and V503
3e. Poor regulation: +150-volt supply	3e. V503
4e. +400-volt supply output is too high or too low	4e. +400V ADJ (R505)
5e. Dead unit; fuse is ok	5e. V504
6e. Poor regulation: +120-volt supply	6e. V505 and V506
7e. +120-volt supply output is too high or too low	7e. +120V ADJ (R515)
8e. Poor regulation: —85-volt supply	8e. V506
9e. No calibrator pattern: MULTIPLIER set to CAL	9e. V507; see 1a

TABLE 4-5
VOLTAGE MEASUREMENTS

NOTES: 1. All voltage measurements taken from tube socket to chassis and are dc and positive unless otherwise indicated
2. All measurements taken with a 20,000-ohm/voltmeter unless otherwise indicated
3. *Indicates measurement with VTVM
4. Tube heater voltage measures 6.3 volts ac between pins designated □ and △; measures ±120 volts with respect to ground unless otherwise indicated

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
VERTICAL DEFLECTION AMPLIFIER										
Notes on local measuring conditions a) Set VOLTS PER DIVISION to OFF b) Set up other front-panel controls for a centered spot c) V105 & V106 voltages vary with Y POSITION and Y LIN (R145) setting										
V101	ECC91/6J6	55	55	0	6	0	0	1.4	.....	.....
V102	ECC82/12AU7-Y	75	55	56	0	12.0	75	55	56	6
V103	12AU6	75	76	12	0	137	165	76	.....	.....
V104	12AU6	75	76	12	0	137	165	76	.....	.....
V105	6CL6	140-150	135-150	210-230	□	△	220-340	140-150	210-230	135-150
V106	6CL6	140-150	135-150	210-230	□	△	220-340	140-150	210-230	135-150
HORIZONTAL DEFLECTION AMPLIFIER										
Notes on local measuring conditions a) Set X SELECTOR to OFF b) Set up other front-panel controls for a centered spot c) V202 & V203 voltages vary with X POSITION and X LIN (R218) setting										
V201	ECC82/12AU7-Y	400	0	25	□	□	400	0	25	△
V202	ECC82/12AU7-Y	50-95	24.5-25	24-29	□	□	50-95	24.5-25	29-85	△
V203	ECC82/12AV7	160-400	50-95	85-100	□	□	160-400	50-95	85-100	△
SYNC AND SWEEP CIRCUITS										
Notes on local measuring conditions a) Set X SELECTOR TO CAL SWEEP b) Set SWEEP MODE fully CCW and position the spot five centimeters left of center										
V301	ECC81/12AT7	107	50	57	□	□	102	6.2*	22	△
V302	ECC81/12AT7	114	115	114	□	□	115	50	55	△
V303	6U8A	320	115	187	□	△	285	115	115	107
V304	ECC81/12AT7	400	115	120	□	□	340	43	49	△
V305	0G3	208	120	208	120	208	120	120	.....	

TABLE 4-5. VOLTAGE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
CRT, BEAM GATE, AND RF SUPPLY										
V401	5AQP—	.....	.....	—20 to —115	.....	0 to 380	.....	.....	.....	—2500
V402	1X2-A		DO	NOT	MEASURE					
V403	ECC82/12AU7-R	115	—1.5*	.....	□ HV	□ HV	73	—1.5*	.....	△ HV
V404	6AQ5A	—130*	0	□ HV	△ HV	400	75	—130*	.....	.....
V405	ECC82/12AU7-R	60	—16	0	□ HV	□ HV	55	—14	0	△ HV
		65	0	0	□ HV	□ HV	69	—18	0	△ HV
V406	6AL5	115	—120	○ HV	△ HV	DO		NOT		MEASURE

CAUTION

V401, V402, V405, and V406 heaters are connected to the —HV supply

Notes on local measuring conditions

a) All V401 measurments taken with respect to pin 2; measurements at pins 3 and 5 vary with INTENSITY and FOCUS settings respectively. See schematic for other pertinent voltages

b) Plate cap of V402 measures —2500 volts with respect to ground

c) All V405 and V406 measurements taken with respect to pin 3 or 8 of V405

d) Upper reading of V405 measured with sweep on; lower reading with sweep off

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
HEATER AND LOW-VOLTAGE SUPPLY										
V501	6U8A	400	150	280	□	△	340	150	192	178
V502	6AS7-GA	340	540	400	340	540	400	□	△	.....
V503	0A2	150	0	.....	0	150	.....	0	.....	.....
V504	5V4-GA	.....	540	.....	450 ac	.....	450 ac	.....	540	.....
V505	6U8A	400	—4*	115	□	△	105	0	115	105
V506	0G3	0	—85	.....	—85	0	.....	—85	.....	.....
V507	6AL5	150	0	□	△	60	0	60	.....	.....
RT501	4H3	.....	12	.....	.....	.....	6	.....	.....	.....
RT502	9-4D	6	22	.....	.....	.....	.....	.....	.....	.....

NOTE: V504 heater measures 5.3 volts ac across pins 2 and 8

TABLE 4-6
RESISTANCE MEASUREMENTS

NOTES: 1. All resistance measurements taken from tube socket to chassis unless otherwise indicated
2. All resistance measurements are in ohms; K = thousand, M = million
3. Do not take readings immediately after turning off equipment

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
				VERTICAL DEFLECTION AMPLIFIER						
				Note: Set VOLTS PER DIVISION to OFF and MULTIPLIER to X1						
V101	ECC91/6J6	Inf	Inf	0	1.2	100K	100K	200K	.....	.....
V102	ECC82/12AU7-Y	65K	28K	Inf	0	2.4	65K	28K	Inf	4.4
V103	12AU6	65K	9100	2.4	0	42K	36K	9100	.....	.....
V104	12AU6	65K	9100	2.4	0	42K	36K	9100	.....	.....
V105	6CL6	7500-10K	42K	95K	15K	15K	50K	7500-10K	95K	42K
V106	6CL6	7500-10K	42K	95K	15K	15K	50K	7500-10K	95K	42K
				HORIZONTAL DEFLECTION AMPLIFIER						
				Note: Set X SELECTOR to OFF						
V201	ECC82/12AU7-Y	36K	100	5-8	15K	15K	36K	100	5-8	15K
V202	ECC82/12AU7-Y	100K	8K	2.8-4.2	15K	15K	100K	8K	2.8-4.2	15K
V203	ECC82/12AV7	68K	100K	12K	15K	15K	68K	100K	12K	15K
				SYNC AND SWEEP CIRCUITS						
				Note: Set (SWEEP) MULTIPLIER to X1						
V301	ECC81/12AT7	19K	390K	39K	15K	15K	22K	2.2M	12K	15K
V302	ECC81/12AT7	260K	65K	15K	15K	15K	16K	50K	38K	15K
V303	6U8A	50K	98K	Inf	15K	15K	45K	6500	6500	33K
V304	ECC81/12AT7	36K	26K	18.5K	15K	15K	Inf	Inf	Inf	15K
V305	CG3	87K	18K	87K	87K	87K	Inf	Inf	18K	

TABLE 4-6. RESISTANCE MEASUREMENTS (Continued)

SYMBOL	TYPE	1	2	3	4	5	6	7	8	9
CRT, BEAM GATE, AND RF SUPPLY										
NOTES: a) All V401 measurements taken with respect to pin 2; pins 1 and 14 measure 39K ohms. See schematic for other pertinent measurements b) Plate cap of V402 measures 8 megohms c) All V405 and V406 measurements taken with respect to pin 2 of V406										
V401	5AQP—	39K	0	375K	Inf	1.35M	Inf	Inf	Inf	9M
V402	1X2-A	Resistance of pins 1 through 9 measure approximately 80 ohms								
V403	ECC82/12AU7-R	675K	1.4	0	15K	15K	90K	78K	0	15K
V404	6AQ5A	130K	0	15K	15K	37K	100K	130K	.....	.....
V405	ECC82/12AU7-R	270K	340K	Inf	175K	175K	280K	350K	Inf	175K
V406	6AL5	220K	0	175K	175K	Inf	.....	Inf	.....	.....
HEATER AND LOW-VOLTAGE SUPPLY										
V501	6U8A	36K	500K	100K	15K	15K	350K	36K	Inf	200K
V502	6AS7-GA	350K	150K	36K	350K	150K	36K	15K	15K	.....
V503	0A2	38K	0	.....	0	38K	.....	0	.....	.....
V504	5V4-GA	.....	150K	.....	60	.....	60	.....	150K	.....
V505	6U8A	38K	240K	15K	15K	15K	500K	0	15K	500K
V506	0G3	0	150K	.....	150K	0	.....	150K	.....	.....
V507	6AL5	35K	0	15K	15K	1.8M	0	1.8M	.....	.....
RT501	4H3	.....	2.4	.....	.....	.....	.....	1.2	.....	.....
RT502	9-4D	1.2	3.2	.....	.....	.....	.....	2.4	.....	.....

SECTION 5
ELECTRICAL PARTS LIST AND SCHEMATICS

Symbol	Du Mont Part Number	Description
CAPACITORS		
(All capacitors are fixed, ceramic, ±5%, 500 V unless otherwise specified)		
C101	0318 1140	paper, 0.1 µf, +20 −10%, 1000 V
C102	0312 8420	variable, 5-25 µµf, 350 V
C103	0305 5170	mica, 100 µµf
C104	0312 8420	variable, 5-25 µµf, 350 V
C105	0302 2010	mica, 1000 µµf 300 V
C106	0312 8420	variable, 5-25 µµf, 350 V
C107	0303 3380	mica, 6800 µµf, 300 V
C108	0315 4620	1000 µµf, ±10%, 1000 V
C109	0313 7840	0.01 µf, ± 20 µµf
C111	0305 5010	mica, 22 µµf
C112	0313 7840	0.01 µf, ±20 µµf
C113	0313 8780	electrolytic, 8 µf, +100−10%, 150V
C114	0316 6750	2700 µµf, ±20%
C201	0301 7460	paper, 0.1 µf, ±20%, 600 V
C202	0312 8420	variable, 5-25 µµf, 350 V
C203	0305 5170	mica, 100 µµf
C204	0312 8420	variable, 5-25 µµf, 350 V
C205	0305 5170	mica, 100 µµf
C206 & C207	0313 3900	composition, 3.3 µµf, ±10%
C210	0305 5370	mica, 10 µµf
C301	0313 9610	0.02 µf, +100 −0%, 450 V
C303 & C304	0313 8390	paper, 0.33 µf, ±10%, 100 V
C305 & C306	0305 5010	mica, 22 µµf
C307	0313 9610	0.02 µf, +100 −0%, 450 V
C308	0313 3930	composition, 5.6 µµf, ±10%
C309	0313 9610	0.02 µf, +100 −0%, 450 V
C311	0313 3470	composition, 0.68 µµf
C312	0312 8400	variable, 1.5-7 µµf, 350 V
C313	0312 8420	variable, 5-25 µµf, 350 V
C314	0305 5220	mica, 160 µµf
C315	0316 1530	mica, 1980 µµf, ±1%
C316	0312 5671	assembly, paper, 0.02 µf, ±1%, 200 V
C317	0312 5681	assembly, paper, 0.2 µf, ±1%, 200 V
C318	0312 5691	assembly, paper, 2 µf, ±1%, 200 V
C319	0313 9610	0.02 µf, +100 −0%, 450 V
C321 & C322	0313 9610	0.02 µf, +100 −0%, 450 V
C323	0305 5250	mica, 220 µµf
C324	0313 9610	0.02 µf, +100 −0%, 450 V
C325	0319 0891	electrolytic, 1 µf, +250 −10%, 250 V
C401	0313 9610	0.02 µf, +100 −0%, 450 V
C402 & C403	0316 9870	5000 µµf, +100 −0%, 3000 V
C404	0316 9080	470 µµf, ±20% 4000 V
C405 to C408	0316 9370	5000 µµf, +100 −0%, 3000 V
C409 A, B	0311 6740	paper, 25/25 µf, +20 −10%, 600 V
C411	0302 2010	mica, 1000 µµf, 300 V
C412	0314 6090	1.5 µµf, ±0.5 µµf, 5000 V
C413	0312 6620	paper, 0.1 µf, ±20%, 200 V
C414	0314 1120	0.1 µf, 400 V
C415	0305 5640	mica, 68 µµf, ±10%
C416	0314 1120	0.1 µf, 400 V
C501 A, B, C	0314 3440	electrolytic, 20/40/10 µf, +40 −10%, 450/250/250 V
C502	0312 7620	paper, 0.1 µf, ±20%, 400 V
C503	0312 6620	paper, 0.1 µf, ±20%, 200 V
C504	0315 4620	1000 µµf, ±10%, 1000 V
C505 & C506	0301 4460	electrolytic, 125 µf, +50 −10%, 350 V
C507	0313 9610	0.02 µf, +100 −0%, 450 V
C508	0312 6620	paper, 0.1 µf, ±20%, 200 V
C509	0314 8830	electrolytic, 12 µf, +100 −10%, 250 V
C511	0317 8450	electrolytic, 100 µf, 250 V
C512	0318 7370	electrolytic, 1000 µf, +40 −10%, 12 V
C513	0316 3430	electrolytic, 1000 µf, +40 −10%, 15 V
C514	0316 3420	electrolytic, 1000 µf, +40 −10%, 30 V
CRYSTALS		
CR301 & CR302	2600 1220	1N69
RECTIFIERS (Metallic)		
CR501	2600 5000	selenium, 50 ma dc
CR502	2600 1780	selenium, 1.5 amperes dc
NEON REGULATORS		
E301 & E302	1200 8931	lamp, glow
FUSES		
F501	1100 5220	2.5 amperes, slow blow (115-volt operation)
F501	1100 0970	1.25 amperes, slow blow (230-volt operation)
LAMPS		
I501 to I505	1200 1310	incandescent, miniature bayonet, 150 ma, 6.3 V
CONNECTORS		
J101 to J103	5101 2551	post, binding, black
J201 & J202	5101 2551	post, binding, black
J301 to J303	5101 2551	post, binding, black
INDUCTOR		
L401	2100 3800	fixed, 6.8 mh
RESISTORS		
(All resistors are in ohms, fixed, composition, ±10%, ½ W unless otherwise specified)		

Symbol	Du Mont Part Number	Description
R101	0228 6230	film, 2M, ±1%
R102	0228 5490	film, 250K, ±1%
R103	0228 5760	film, 20.4K, ±1%
R104	0228 5520	film, 2K, ±1%
R105 & R106	0228 6230	film, 2M, ±1%
R107	0107 5900	variable, 100, ±20%
R108	0203 2170	2.2M
R109	0203 2010	100K
R110	0203 6870	43K, ±5%, 2 W
R111	0203 2010	100K
R112	0228 5830	film, 47K, ±1%
R113	0228 5560	5600, ±1%
R114	0228 5810	film, 39K, ±1%
R115 A, B	0107 1352	variable, 15K/2K, ±20%
R116	0228 5740	film, 18K, ±1%
R117 & R118	0222 0000	wire wound, 55.75K, ±1%, ¾ W
R119	0228 5660	film, 10.3K, ±1%
R120	0203 0680	6800, ±5%
R121	0228 5620	film, 9300 ±1%
R122	0228 5540	film, 3100, ±1%
R123	0228 5500	film, 1030, ±1%
R124	0228 5870	film, 93K, ±1%
R125	0228 5790	film, 31K, ±1%
R126	0228 5660	film, 10.3K, ±1%
R127	0203 2150	1.5M
R128	0107 4430	variable, 5M, ±20%
R129	0203 2150	1.5M
R130	0228 5590	film, 7250, ±1%
R131	0108 0950	variable, 2500, ¼ W
R132	0203 1760	820
R133	0107 2230	variable, 250, ¼ W
R134	0203 1760	820
R135	0230 4620	wire wound 9100, ±5%, 3 W
R136 & R137	0228 5710	film, 15K, ±1%
R138	0203 2030	150K
R139	0100 8180	variable, 500K, ±20%, ¼ W
R140/S103	0108 0900	variable, 2500, ¼ W plus switch
R141	0203 2030	150K
R142 & R143	0203 1660	120
R144	0230 4600	wire wound, 6800, ±5%, 3 W
R145	0107 4750	variable, wire wound, 2 K, ±20%, 1.5 W
R146	0203 6910	62K, ±5%, 2 W
R147	0210 9360	wire wound, 20K, ±5%, 5 W
R148	0203 6680	6800, ±5%, 2 W
R149	0203 6750	13K, ±5%, 2 W
R152 & R153	0203 2170	2.2M
R201	0204 1270	2M, ±5%
R202	0204 1040	220K, ±5%
R203	0204 1270	2M, ±5%
R204	0203 1170	750K, ±5%
R205	0203 1150	620K, ±5%
R206	0105 6330	variable, 250K, ±20%, ¼ W
R207 & R208	0203 1650	100
R209	0203 0650	5100, ±5%
R211	0105 6320	variable, 10K, ±20%
R212	0203 0650	5100, ±5%
R213	0100 8160	variable, 10K, ±20%, ¼ W
R214	0203 1740	560
R215	0203 1650	100
R216 A, B	0107 1341	variable, 1500/1M, ±20%, ¼ W
R217	0203 0640	4700, ±5%
R218	0103 3270	variable, 10K, ±20%, 2 W
R219	0203 0830	30K, ±5%
R220	0203 0900	56K, ±5%
R221	0203 7960	39K, 2 W
R222	0203 0830	30K, ±5%
R223	0203 6740	12K, ±5%, 2 W
R224 & R225	0203 6840	33K, ±5%, 2 W
R226 & R227	0203 2170	2.2M

Symbol	Du Mont Part Number	Description
R301	0203 2170	2.2M
R302	0203 0740	12K, ±5%
R303	0203 1800	1800
R304	0203 1890	10K
R305	0100 8170	variable, 200K, ±20%, ¼ W
R306	0203 1930	22K
R307	0105 6320	variable, 10K, ±20%
R308	0203 1930	22K
R309	0203 2080	390K
R311	0203 1850	4700
R312 & R313	0203 2010	100K
R314	0203 1960	39K
R315	0203 1800	1800
R316	0228 5780	film, 30K, ±1%
R317	0228 5970	film, 180K, ±1%
R318 A, B	0105 8391	variable, 50K/25K, ±20% (part of switch assembly, S201)
R319	0228 6080	film, 560K, ±1%
R321	0210 9360	wire wound, 20K, ±5%, 5 W
R322	0228 6040	film, 270K, ±1%
R323	0105 6330	variable, 250K, ±20%, ¼ W
R324	0203 2080	390K
R325	0228 5970	film, 180K, ±1%
R326	0222 5020	10K, ±5%, 2 W
R327	0203 2170	2.2M
R328	0203 1650	100
R329	0203 1740	560
R331	0203 6720	10K, ±5%, 2 W
R332	0228 6060	film, 450K, ±1%
R333	0203 3900	56K, ±5%, 1 W
R334	0228 6130	film, 900K, ±1%
R335	0228 6180	film, 1.35M, ±1%
R336	0228 6240	film, 2.25M, ±1%
R337	0107 6810	variable, 5M, ±20%, ¼ W
R338	0203 1110	430K, ±5%
R339	0203 1650	100
R341	0203 6750	13K, ±5%, 2 W
R342	0203 3680	6800, ±5%, 1 W
R343	0203 1650	100
R344	0107 5130	variable, 25K, ±20%, 1 W
R345	0203 6780	18K, ±5%, 2 W
R346	0203 1930	22K
R347	0203 1890	10K
R348	0203 1930	22K
R349	0203 2080	390K
R351	0203 1650	100
R401	0100 9080	variable, 250K, ±20%, 2 W
R402	0203 2170	2.2M
R403	0203 1960	39K
R404	0203 2130	1M
R405	0106 3340	variable, 1M, ±20%, 2 W
R406 to R408	0203 8160	1.8M, 2 W
R409	0107 1373	variable, 1.5M, ±20%
R411	0210 0810	wire wound, 4700
R412	0203 2130	1M
R413	0203 2090	470K
R414	0203 1250	1.6M, ±5%
R415 & R416	0203 8020	120K, 2 W
R417	0203 2030	150K
R418	0203 2010	100K
R419 & R421	0203 1070	300K, ±5%
R422	0203 2010	100K
R423	0107 1371	variable, 250K, ±20%
R424 & R425	0203 2110	1.5M
R426	0203 1010	160K, ±5%
R501	0228 6060	film, 450K, ±1%
R502	0228 6260	film, 360K, ±1%
R503	0232 3620	wire wound, 12K, ±5%, 10 W
R504	0228 8320	film, 910K, ±1%
R505	0102 4230	variable, 50K, ±20%, ¼ W

Symbol	Du Mont Part Number	Description
R506	0203 2090	470K
R507	0228 8310	film, 820K, ±1%
R508	0203 2050	220K
R509	0203 8020	120K, 2 W
R511	0203 6940	82K, ±5%, 2 W
R512 & R513	0203 5050	220K, 1 W
R514	0203 1050	240K, ±5%
R515	0103 3300	variable, 50K, ±20%, 2 W
R516	0203 2010	100K
R517	0203 1010	160K, ±5%
R518	0203 2090	470K
R519	0203 3630	4300, ±5%, 1 W
R521	0203 3630	4300, ±5%, 1 W
R522	0203 1530	10
R523	0228 6300	film, 5M, ±1%
R524	0107 1023	variable, 10K, ±20%
R525	0228 8260	film, 11K, ±1%
R526	0203 4300	2.7M, ±5%, 1 W
R527 (S501)	0107 1112	variable, wire wound, 6, 2 W plus (on-off switch)
RT501	0224 2710	current regulator, 4-H3
RT502	0223 5290	current regulator, 9-4D

SWITCHES

(All rotary switches are phenolic and the angle of throw is 30° between positions unless otherwise specified)

S101 & S102	0501 3041	assembly, rotary; 3 sections, 11 positions; 3 sections, 7 positions
S103	See R140	
S201	0501 3052	rotary, 3 sections, 7 positions
——	0501 3051	assembly, consisting of S201 and R318
S301	0501 2601	rotary, 60°, 1 section, 3 positions
S302 & S303	0501 2581	assembly, rotary; 2 sections, 6 positions; 1 section, 5 positions
S501	Part of R527	

TRANSFORMERS

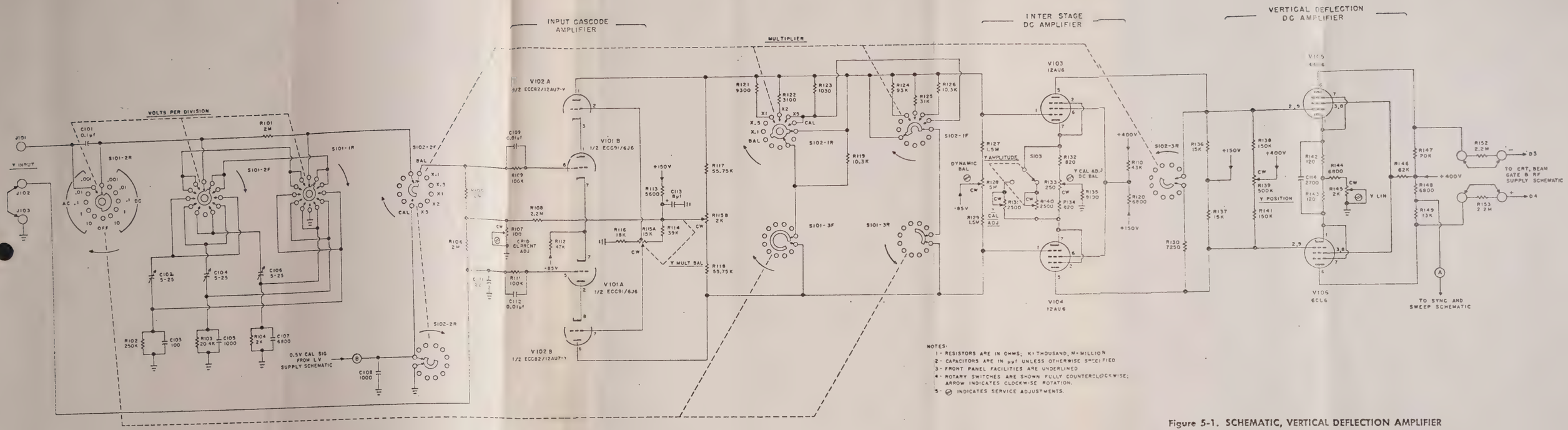
T401	2000 7231	radio frequency, high voltage
T501	2001 0961	power, low voltage (115 V operation)
T501	2001 2211	power, low voltage (230-volt operation)

TUBES

V101	2501 1620	ECC91/6J6
V102	2501 1610	ECC82/12AU7 (yellow tip)
V103 & V104	2500 9110	12AU6
V105 & V106	2500 7820	6CL6
V201 & V202	2501 1610	ECC82/12AU7 (yellow tip)
V203	2500 8220	12AV7
V301 & V302	2501 1690	ECC81/12AT7
V303	2501 1840	6U8A
V304	2501 1690	ECC81/12AT7
V305	2500 9270	0G3
V401*	2500 8700	5AQP1
	2500 8710	5AQP2
	2500 8720	5AQP7
	2500 8730	5AQP11
* Depending on sales order		
V402	2500 6490	1X2-A
V403	2501 1610	ECC82/12AU7 (red tip)
V404	2501 1750	6AQ5A
V405	2501 1610	ECC82/12AU7 (red tip)
V406	2500 0020	6AL5
V501	2501 1840	6U8A
V502	2501 0200	6AS7-GA
V503	2500 0300	0A2
V504	2501 1180	5Y4-GA
V505	2501 1840	6U8A
V506	2500 9270	0G3
V507	2500 0020	6AL5

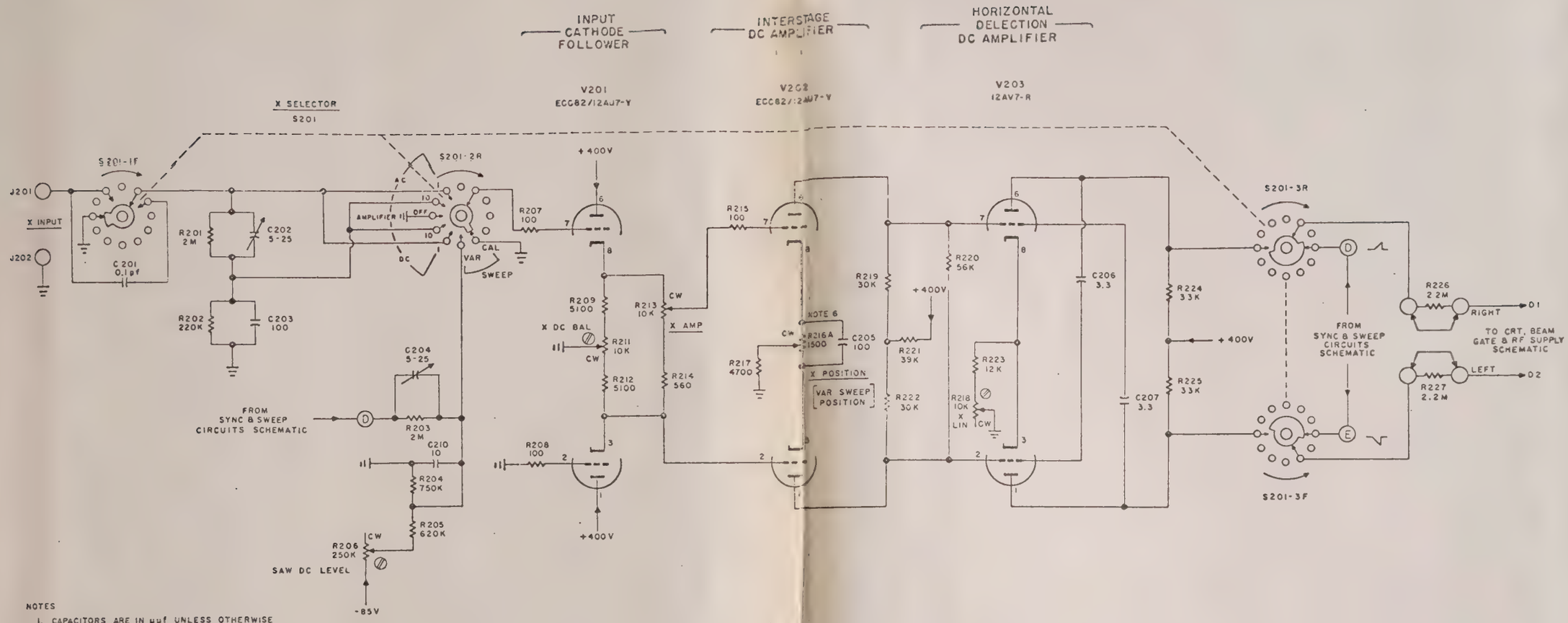
CABLE

W501	5026 9641	assembly, power, electrical, 3-conductor, #18 AWG, 72 inches



NOTES:
1 - RESISTORS ARE IN OHMS; K=THOUSAND, M=MILLION
2 - CAPACITORS ARE IN µµf UNLESS OTHERWISE SPECIFIED
3 - FRONT PANEL FACILITIES ARE UNDERLINED
4 - ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION.
5 - ⊘ INDICATES SERVICE ADJUSTMENTS.

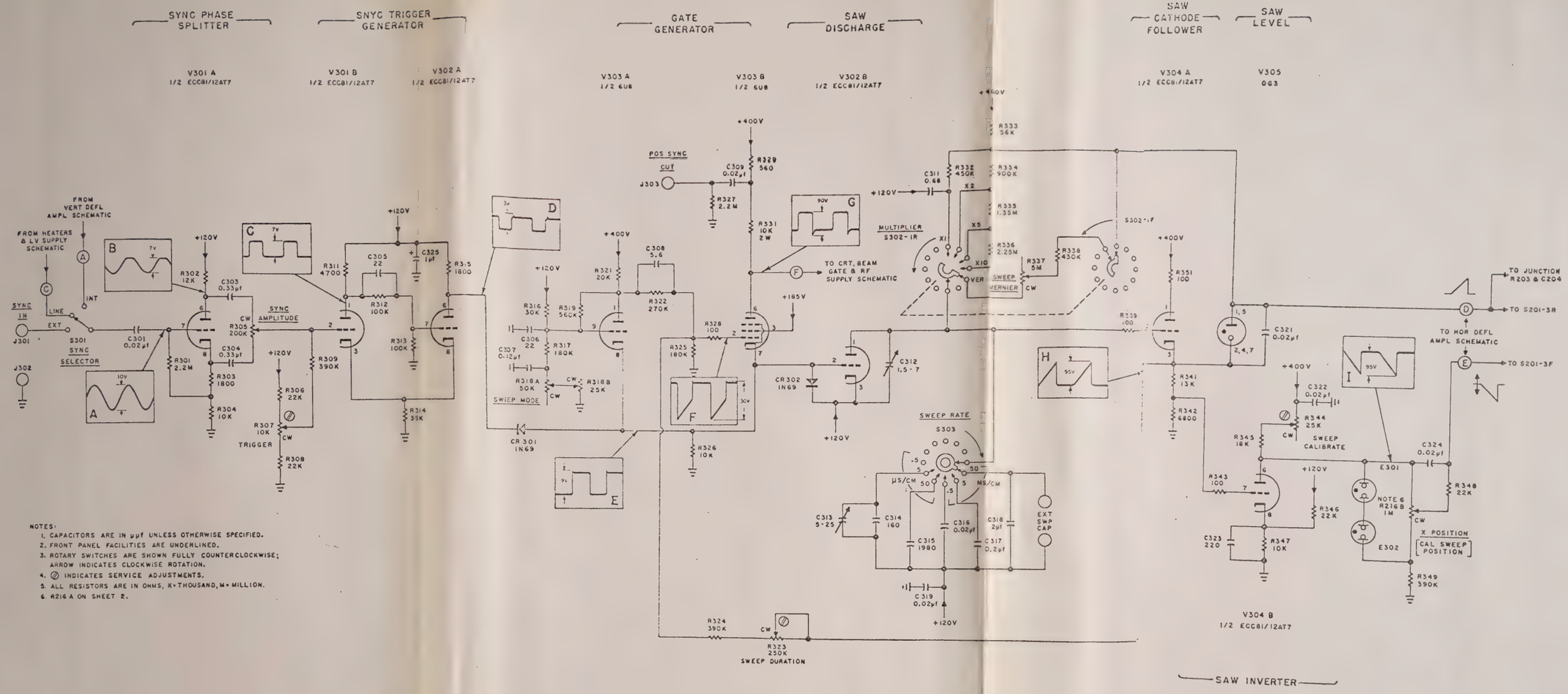
Figure 5-1. SCHEMATIC, VERTICAL DEFLECTION AMPLIFIER DU MONT TYPES 403 and 403-R CATHODE-RAY OSCILLOSCOPES (Reference Drawing 9C001391-4, Sheet 1 of 5, Issue 5)



NOTES

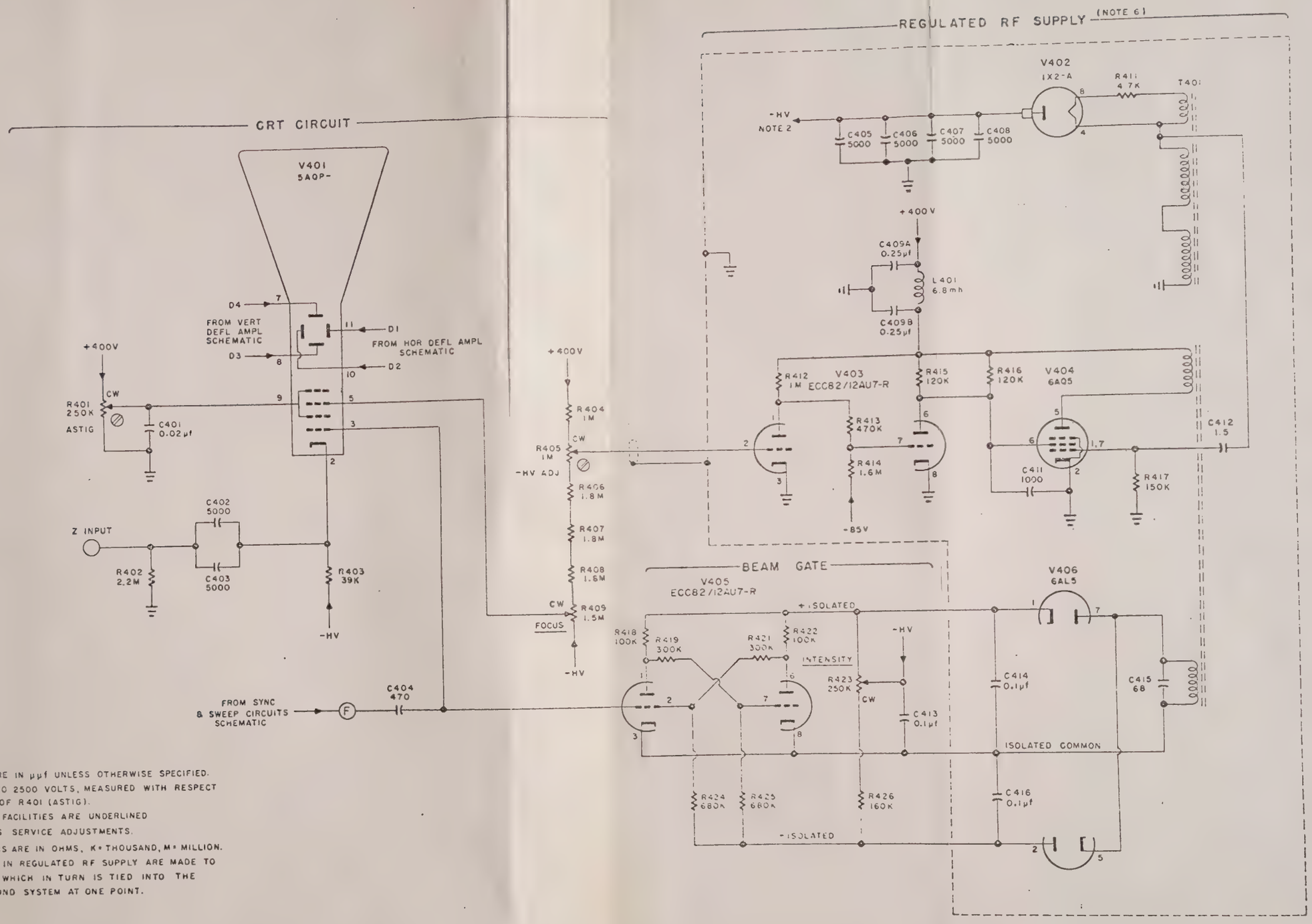
1. CAPACITORS ARE IN μμf UNLESS OTHERWISE SPECIFIED.
2. FRONT PANEL FACILITIES ARE UNDERLINED.
3. ROTARY SWITCHES ARE SHOWN FULLY COUNTER-CLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION.
4. ⊘ INDICATES SERVICE ADJUSTMENTS.
5. ALL RESISTORS ARE IN OHMS, K=THOUSAND, M= MILLION.
6. R216B ON SHEET 3.

Figure 5-2. SCHEMATIC, HORIZONTAL DEFLECTION AMPLIFIER DU MONT TYPES 403 and 403-R CATHODE-RAY OSCILLOSCOPES (Reference Drawing 98001391-4, Sheet 2 of 5, Issue 4)



NOTES:
1. CAPACITORS ARE IN µµf UNLESS OTHERWISE SPECIFIED.
2. FRONT PANEL FACILITIES ARE UNDERLINED.
3. ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION.
4. ⊘ INDICATES SERVICE ADJUSTMENTS.
5. ALL RESISTORS ARE IN OHMS, K=THOUSAND, M=MILLION.
6. R216 A ON SHEET 2.

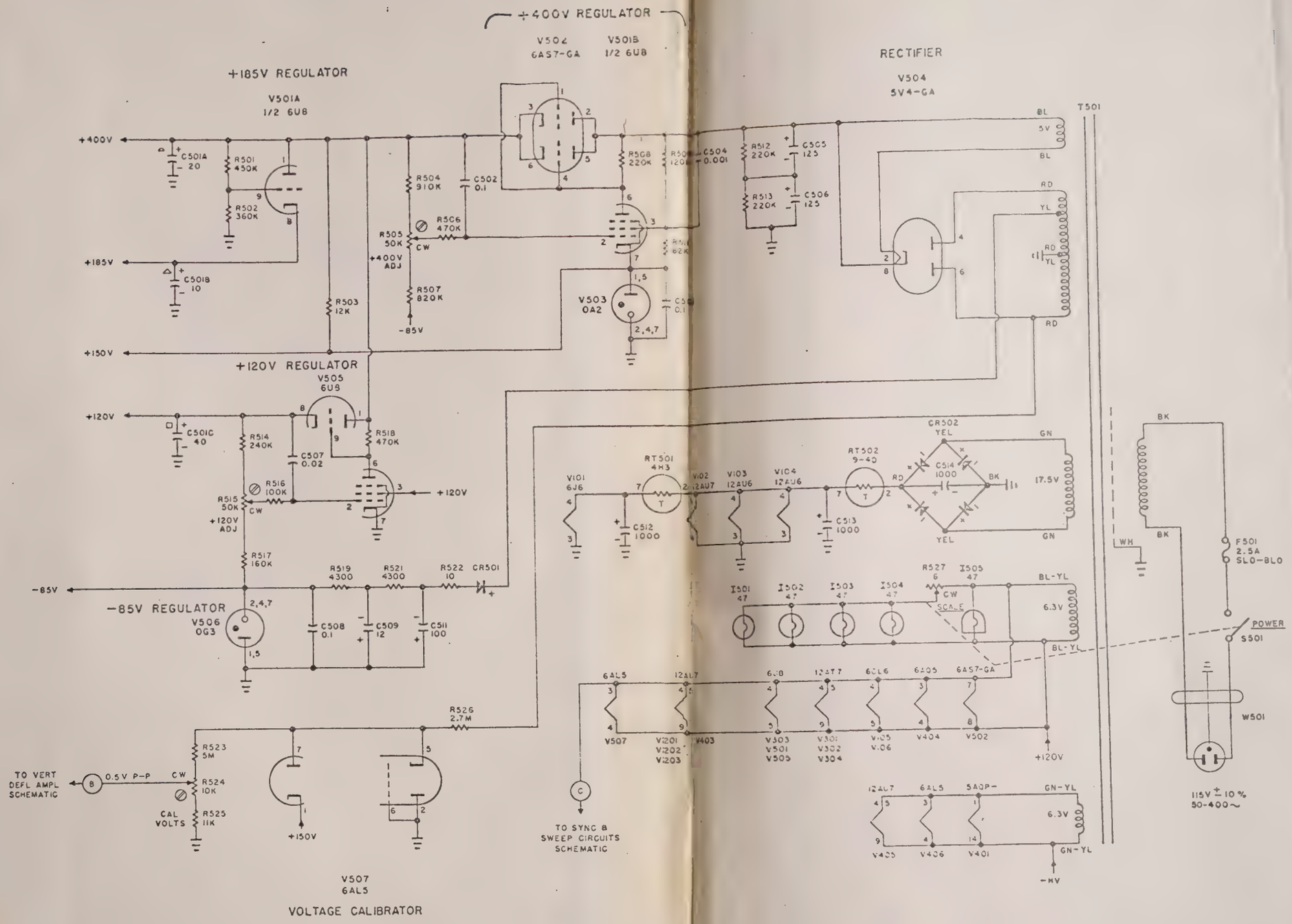
Figure 5-3. SCHEMATIC, SYNC AND SWEEP CIRCUITS
DU MONT TYPES 403 and 403-R CATHODE-RAY OSCILLOSCOPES
(Reference Drawing 98001391-4, Sheet 3 of 5, Issue 5)



NOTES

1. CAPACITORS ARE IN µµf UNLESS OTHERWISE SPECIFIED.
2. -HV IS SET TO 2500 VOLTS, MEASURED WITH RESPECT TO THE ARM OF R401 (ASTIG).
3. FRONT PANEL FACILITIES ARE UNDERLINED
4. ⓐ INDICATES SERVICE ADJUSTMENTS.
5. ALL RESISTORS ARE IN OHMS, K = THOUSAND, M = MILLION.
6. ALL GROUNDS IN REGULATED RF SUPPLY ARE MADE TO SHIELD CAN, WHICH IN TURN IS TIED INTO THE COMMON GROUND SYSTEM AT ONE POINT.

Figure 5-4. SCHEMATIC, CRT, BEAM GATE AND RF SUPPLY
DU MONT TYPES 403 and 403-R CATHODE-RAY OSCILLOSCOPES
(Reference Drawing 98001391-4, Sheet 4 of 5, Issue 2)



NOTES:
1. CAPACITORS ARE IN μf UNLESS OTHERWISE SPECIFIED.
2. ⊘ INDICATES SERVICE ADJUSTMENT.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. ALL RESISTORS ARE IN OHMS, K = THOUSAND, M = MILLION.

Figure 5-5. SCHEMATIC, HEATERS AND LOW-VOLTAGE SUPPLY DU MONT TYPES 403 and 403-R CATHODE-RAY OSCILLOSCOPES (Reference Drawing 98C01391-4, Sheet 5 of 5, Issue 6)

ADDENDUM

AFFECTING INSTRUCTION MANUAL OF

Types 403 and 403-R Oscilloscope (Manual #6702 8582)

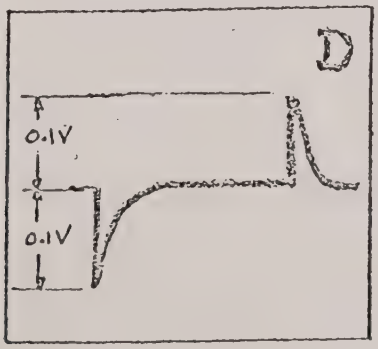
The changes described below were made in order to improve sync stability by differentiating sync pulse.

	Symbol	Part Number	Description
Add	CR303	2600 1220	Semiconductor, 1N69
Add	L301	2101 3000	Inductor, fixed 47 uh

Schematic Drawing 9800 1391-4, sheet 3, is revised as follows:

a. CR303, 1N69, is added between pin 3 of V304A and R323 with polarity as per sketch:

b. L301, 47 uh, is added in parallel with R315. Waveform [D] is changed as per sketch:



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